THE JOURNAL OF ENGINEERING EDUCATION

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Published by THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

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VOL. XXIX., NO. 7 | MARCH, 1939 | Subscription Price $3.00 per year
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Published by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
K. T. Compton, S. B. Earle, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of March 3, 1870.

New Series Vol. XXIX, No. 7 | MARCH, 1939 | Subscription Price, $3.00 per year. Single Copies, 50 cents

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ENGINEERING SCHOOLS AND UNIONS*

By V. T. BOUGHTON

Managing Editor, *Engineering News-Record*

What I have to say on the effect of the unionization of technical men on college students and the engineering schools can be summed up in two words—very little. However, the union movement may become so important to the young graduate that it is well that teachers in our engineering schools be in a position to advise their students wisely on this subject.

The first essential to a study of the union movement is to recognize that there is nothing fundamentally wrong in a trade union. A lot of engineers do not hold to that view; they maintain that professionalism and unionism are incompatible. When analyzed this view is found to be mostly wishful thinking. It finds its origin in the natural revulsion of the educated man to trade unions as we know them today and to the tactics of union organizers.

Yet the purpose of a trade union is laudable. It is to get for its members by collective action what the individual cannot get alone. Our state professional societies have much the same purpose, but employ different methods. So far they have limited themselves chiefly to legislative matters and civil service questions, but in New York State the state society has taken a hand in getting better pay for engineers on WPA, a move, by the way, in which the A. S. C. E. coöperated. There is no reason why, ultimately, the state societies might not represent employees in collective bargaining with employers. Developed from that angle, you would have the ideal union with few objectionable features.

But the trade union as we have it today is quite different from the ideal agency for collective bargaining. The two principal unions, the Technical Engineers', Architects', and Draftsmen's Unions and the Federation of Architects, Engineers, Chemists and Technicians, have many bad features carried over from the older trade unions on which they are patterned. In the first place their methods of working include threat of strike, exaggeration of issues, verbal abuse of the whole employer class, misstatement of facts, and like tactics which are distasteful to the educated or cultured man. This is especially true of the F. A. E. C. T. More fundamental, however, are the matters of classification of men,

* Presented at the meeting of the Allegheny Section, S. P. E. E., November 4–5, 1938, at the University of Pittsburgh.

promotion according to seniority, and limitation on production, all of which seem to be inseparable from unionization.

As pay rates and working hours are the chief concern of unions, it is essential that all men included in the union be classified as to work done and pay. And once a man finds himself in a particular group he finds also that about the only way to get out of that group is by the slow process of seniority. The older man, regardless of ability, gets the preference unless he actually lacks the technical qualifications. Of course we have much the same situation in civil service except that major changes now are made on the basis of examination. Then there is the tendency in large groups to check the production of the ambitious worker to keep him from showing up the rest of the group, a leveling process which is one of the chief drawbacks for the ambitious man in any regimentation.

And here is where the question of professionalism and unionism comes in. Many engineers maintain that a man cannot bind himself to abide by the limits a union sets up and at the same time maintain a professional approach to his work. The best answer I can give is that I have seen many trainmen and enginemen in the strongest unions in this country take what to me is a professional approach to their work—willingness to go beyond the normal demands of their job to make it a success, or to meet an emergency; putting their employers' interest above their own. Put the ambitious, professionally minded man in the worst kind of a union and he still will rise above his environment. Abiding by the decisions of his organization may be difficult at times, but it will not kill his professional spirit.

Turning now to your particular problem, what do the technical unions have to offer to the engineering graduate? I think they have little to offer except to the man who finds himself one of many engineers employed by a large corporation. To these men, temporarily at least, union membership may be an advantage. Certainly I would not advise the young engineer going into a big corporation where the engineers are already unionized to hold aloof. He might better join the union and throw his weight with those who would raise the union's standards. Also, an engineers' union in such an organization has the desirable effect of keeping engineers together as a separate bargaining agency. Without a union in a highly unionized plant they are swallowed up in a big company union.

Take the West Allis plant of the Allis-Chalmers Mfg. Co., for example. The engineers of that plant had a small local union of their own when the C. I. O. came in and organized the plant, seeking to get itself named the bargaining agent for all workers. The

engineers union and some others held out and subsequently got the National Labor Relations Board to rule that they should be separate bargaining agencies. Thus they are in a position to get a hearing for their peculiar troubles that they would not get as a small minority among the mechanics who are uninterested in their problems.

A young engineer going into that plant, it seems to me, would be far better off to throw his lot in with the engineers union to help raise its standards than to stay out. And of course where a closed shop exists he has no alternative.

In the City of Seattle, the whole City engineering department, except the city engineer himself, who is ineligible, has joined the T. E. A. D. U., including O. A. Piper, past president of the Seattle Section, A. S. C E. Similarly, the Minnesota Highway Department is largely unionized. Of course both states are centers of labor activity, but wide acceptance of unionization by their engineers goes to show that the union question needs to be faced with horse sense rather than with the theoretical idealism of dear old educators like Dr. Riggs or Dr. Mead.

Your students should be shown both sides of the picture. Blind following of the idealist who tells them that the only way to high professional position is to avoid the unions will lead to just as much disillusionment as will blind following of the labor organizer who promises high pay and easy working conditions.

No one can deny that young engineers and engineering assistants have been and still are exploited through low pay and long hours. Even some of the most ethical leaders of our profession have not been above exploitation under the guise of giving the young man practical experience. The unions have helped materially in checking this practice, which was particularly bad among speculative builders in New York a few years ago. The Wagner Labor Relations Act and the new Fair Labor Standards Act, both fostered by organized labor, have done much to spread the gains and make them permanent—bad as both acts are in other respects.

Curious as it may seem, the labor relations act and the fair-labor-standards act may prove to be the end of smaller unions like the technical unions because once the principle of collective bargaining is widely accepted by employers, and once the small groups of employees realize that even they can appeal directly to the NLRB if need be, there will be little reason to pay dues to support national officers and to pay national organizers.

It is impossible to determine how many real engineers are members of unions, but I do not think the number is large, despite the claims of the F. A. E. C. T. When the A. S. C. E. Unionization

Committee made its study last fall the total membership was put at around 12,000, but the great bulk of these men, so far as we could tell, were in the sub-professional class, relatively few being graduate engineers. The chief appeal of the unions always will be to the sub-professional class. I can't get excited about the possibility of any large number of engineers going into unions.

If the state societies of professional engineers would take in the higher grade men in the sub-professional class—chiefly those who aspire to be licensed—putting them in an associate grade, and would take a real interest in their welfare, there would be no reason to worry about the trade unions.

APPLICATIONS OF THE PHYSICAL SCIENCES

By SAUL B. ARENSON

Professor of Inorganic Chemistry, University of Cincinnati

For the fifth consecutive year, the University of Cincinnati will present its annual series of Saturday morning orientation lectures "The Applications of the Physical Sciences" to certain invited high school junior and senior students.

Teachers of the physical sciences in all high schools (private, public, and parochial) within 25 miles of Cincinnati will be asked to select those students who rank in the upper 10 per cent of their classes of chemistry, physics, geology, and advanced mathematics. Only those students will receive a free ticket to permit them to enjoy a series of eight demonstration lectures, highly illustrated by actual experiments, slides, and motion pictures.

If this year's series runs true to form, almost 90 per cent of the 1,100 invited students will attend the first four or five lectures; spring fever and inertia causing a drop in attendance later in the series.

It has been the opinion of some educators that physics, for example, as it is taught in many high schools, is taught as physics, with no effort being made to explain the many ways that the subject matter is related to the other physical sciences. One of the objects of these lectures is to correct that condition. Another useful purpose is to show the modern industrial and engineering applications of the facts which they learn in their high school classes.

There are two series of eight lectures given in alternate years. Thus a good student will be able to hear all of the lectures during the last two years of his high school career. To show the variety and type of subject matter, the two series are outlined in detail.

Last year the lectures were:

1. "The Physics of Air in Motion," Samuel J. M. Allen, Professor of Experimental Physics.

A theoretical discussion of the principles involved in the motion of air past objects and of objects through the air, showing the connection between pressure and velocity known as the Bernoulli and Venturi principles. Actual demonstrations of the above relations—the curving of golf balls, tennis balls, and baseball; hydrodynamic problems, phenomena of light balls on air jets; airplanes and streamlining.

2. "On Oxidation and Combustion," Henry M. Goettsch, Professor of Inorganic Chemistry.

The nature of combustion has occupied the attention of thinking men during past ages. Is matter "destroyed" when it burns up? Just what happens when this occurs? What about the phlogiston theory? A series of experiments and demonstrations will be shown to help give the answer to those questions.

3. "Diesel Engines," Reuel L. Smith, Assistant Professor of Mechanical Engineering.

A development of the Diesel Engine; its place in modern industry and transportation; general characteristics of internal combustion engines and the unique characteristics of Diesel Engines; the economics of Diesel power. Illustrated by many charts and lantern slides.

4. "Stroboscopy, the Science of Arresting High-Speed Motion," Albert C. Herweh, Instructor in Electrical Engineering.

Several types of stroboscopes described by slides and demonstrations. Viewing of high speed electric fan in motion as though it were actually standing at rest. Use of polarized stroboscopic light for the analysis of stress in airplane propellors in motion. Taking of high speed motion pictures for detailed study of motions which are normally imperceptible will be discussed. In conclusion, motion pictures (shattering of glass, mechanics of splashes), some of which were taken at the rate of 6,000 frames per second, will be shown in ultra-slow motion.

5. "Clay and Clay Products," Harold S. Nash, Professor of Ceramics.

Formation of clays, classification, preparation, shaping, firing, and glazing of clay products. Chemistry of glasses and clays. Actual demonstrations of glaze forming and pottery firing. Lantern slides.

6. "Ancient and Modern Dyes," Hoke S. Greene, Assistant Professor of Chemical Engineering.

The triumph of chemistry in the synthesis of natural dyes and many others not found in nature will be discussed. Demonstrations will be employed to show how dyes are made and used, what causes color in dyes, and how the color may be changed.

7. "Sounds Made Visible," Laurence R. Culver, Associate Professor of Electrical Engineering.

The basic structure of speech and music will be illustrated by oscillographs and loudspeakers. A selected fundamental note in the musical scale, with a few of its overtones, will be generated, shown, and heard. An effort will be made to imitate certain musical instruments. An opportunity will be presented for members of the audience to see their spoken, sung, or whistled notes.

8. "Controlling Soil Erosions," John L. Rich, Professor of Economic Geology.

By cutting forests, plowing fields, and pasturing two steers where there is grass enough for one we have disturbed nature's delicate balance between rainfall, vegetation cover, and slope. Results—fertile soils washed away, river beds silted up, scarcity of water in dry seasons, and

disastrous floods when rains come. Why these changes came about and what can be done about them is the topic of the lecture. Lantern slides and maps. Aerial photographs.

This winter commencing about February 1, on eight successive Saturday mornings these lectures will be heard:

1. "Vibrations, Waves, and Sounds," Robert C. Gowdy, Professor of Physics; Isay Balinkin, Instructor in Physics.

Behavior of various kinds of waves; how energy is transmitted by wave motion. Many demonstrations, including the characteristics of musical sounds and types of vibration used to produce them.

2. "Visible and Invisible Light," Dare A. Wells, Associate Professor of Physics.

"Explanations" of the complete range of "Light" including radio, infra-red, visible, ultra-violet, and gamma rays, with elaborate and startling demonstrations.

3. "Nitrogen of the Air Made Valuable," Reuben S. Tour, Professor of Chemical Engineering.

Descriptions of the chemistry and engineering basic to the main methods of "Nitrogen Fixation"; importance and use of nitrogen compounds. Accompanied by appropriate lantern slides.

4. "From Soft Iron Ore to Hardened Steel," Roy O. McDuffie, Associate Professor of Metallurgy; George M. Enos, Associate Professor of Metallurgy.

Extraction of iron from ores; the necessary refining processes; structure of steel; changes during the hardening by cold work and heat treatment. Actual demonstrations as well as slides and motion pictures.

5. "Building of the George Washington Bridge," Howard B. Luther, Professor of Civil Engineering.

Bridge design and construction; applications of mathematics and mechanics and knowledge of properties of materials; study of geological formation. A description by slides of method of spinning cables, foundation designs, etc.

6. "What Makes it Fly," Bradley Jones, Professor of Aeronautics.

Actual demonstration with model airplane and wind-tunnel. Sample calculations showing how results in windtunnel tests may be used in finding power of full-size wing. Slides.

7. "The Geologist's Share in the Finding of Oil," Walter H. Bucher, Professor of Historical Geology.

Trial and error method of finding pools; origin of pools; relation between oil pools and rock structure; microscopic fossils as clues; and how artificial miniature earthquakes and other geophysical methods reveal underground structures.Lantern slides and charts.

8. "From Galileo to Einstein," Louis Brand, Professor of Mathematics.

Galileo's great discoveries; his investigations supporting the Theory of Copernicus: development of astronomy and mechanics at the hands of Newton and others traced to the present day. Slides and charts.

As one national newspaper mentioned, covering the first talk five years ago, "When a breakfast food company gives away samples of its product, that's good business—but when a university gives away samples of its lectures, that's news." But, of course, it is much more than that. It is not necessary to mention to the readers of this JOURNAL the immense value of these lectures to students in their formative years.

Certainly the university lecturer benefits too—because he comes in contact with a new type of student. If he thinks that he is addressing members of the modern generation, concerned only with "Swing" and football, he will have the thrill of his life when he views the audience of 1,000 or more earnest high school students, spending their own free Saturday mornings in an eagerness to learn more. The many questions that they ask in the hour after the lecture when they are on the platform viewing the experimental apparatus, will more than repay the lecturer for the many hours of work caused by the lecture.

This then is simply a progress report * of an experiment which we believe was unique in educational circles five years ago. Additional information can be secured from the writer.

* First reported as "A Novel Experiment" in *School and Society*, July 4, 1936.

INDUSTRIAL REQUIREMENTS FOR THE PETROLEUM ENGINEER *

By HARRY H. POWER

Professor of Petroleum Engineering, The University of Texas

Many questions arise in current discussions concerning preparation for the profession of petroleum engineer, particularly relative to the best curriculum to follow and the relative emphasis placed upon the so-called fundamentals as compared to that placed upon their application in the specialized courses. The curricula in petroleum engineering are relatively new, and considerable change has been evidenced since the first department was established at the University of Pittsburgh in 1912. What may appear to be the best curriculum in petroleum engineering to-day may not serve for the future, if the needs of the industry and development of engineers to meet the changing order are the primary criteria.

It is platitudinal to say that departments of petroleum engineering should supply sufficient basic training for a lifetime of subsequent study and practice. An entering wedge is provided for young men of certain aptitudes, which facilitates progress as they encounter various experiences, arrive at definite conclusions, and see the results of their work in practice. The succession of problems confronting engineers in the field results in a degree of versatility not ordinarily encountered in other professions. It is apparent that the engineer's ability to think is limited by his mentality, his educational experiences, and his job experiences. In the field of petroleum engineering his lack of job experiences often proves as much of a handicap as a lack of educational experiences. To be of the most value, job experiences should be varied so as to offer numerous possible solutions of the problem.

Changes in Petroleum Engineering

Before the advent of the petroleum engineer, engineering work with producing companies was in most cases handled in various manners. Of course, there was a certain amount of surveying necessary for location of wells, running of property lines and erecting structures. The electrical engineer may also have been consulted to some extent where electric power was in demand. The mechanical engineer started at the designing end, and still finds

* Presented at the Conference on Mineral Technology, at the 46th Annual Meeting, S. P. E. E., College Station, Texas, June 27–30, 1938.

avenues for best work in the plants of equipment manufacturers. It is true that the producing industry is largely mechanical, but principally from an operating point of view. Consequently, fundamental engineering training, regardless of the particular branch studied has permitted young engineers to become efficient operators.

One of the first conceptions of the petroleum engineer confined his efforts to various subsurface problems lying between the field of the geologist and the mechanical engineer. He studied the construction of wells and casing programs, recommended casing points, points for water shut-off, and procedure for the reduction of underground losses of all kinds. He also concerned himself with problems in recovery of oil and gas, and the estimation of reserves. However, the petroleum engineer has been forced to carve his own path throughout the relatively few years of his existence, and has shown conclusively, that original concepts have been broadened materially to include work in many phases of development and production practice. Since the problems presented to the petroleum engineer are many and diverse, unusual versatility is necessary, which is promoted by knowledge of many scientific fundamentals and applied engineering.

Functions of the Petroleum Engineer

The graduate in petroleum engineering serves the oil industry in a manner comparable to the mining engineer in the mining industry. He should understand the principles of geology sufficiently well to solve production problems related to the oil reservoir. He may utilize geology further in connection with exploitation work conducted by production departments after the discovery well has been drilled under the direction of the geological department. The petroleum engineer should also have a basic training in the chemistry of hydrocarbons and the principles of hydrodynamics as applied to underground flow of fluids and means of lifting them to the surface. Although he may not be requested often to design new mechanical devices, yet he should have sufficient training in physics and mechanical engineering to select equipment intelligently and operate it economically and efficiently.

Steel may be aptly termed the "backbone of the oil industry." The metallurgy of steel is perhaps one of the most important basic and usable sciences to be considered by the engineer contemplating a career in the oil industry. Training in this science is necessary to permit intelligent selection of those materials most resistant to fatigue and corrosion. The demands of deeper drilling and pumping require the selection of steels of higher physical properties capable of withstanding fatigue and corrosion of all kinds.

The petroleum engineer should have training in water analysis

in order that he may cope with problems concerning oil field brines, such as their proper disposal and the prevention of damage to streams and property by pollution. He should understand proper methods of coring sands with all improved mechanical and electrical methods. He may be called upon to design casing strings for protection of oil bearing formations and exclusion of extraneous well water. The various methods of stimulating production such as shooting of wells, the acid treatment of limestone formations, reconditioning procedure, repressuring, and water flooding should be thoroughly understood and applied where practical. Other technical projects properly within the field of the petroleum engineer include: spacing of wells, investigation of new methods of lifting the oil, the design of transportation systems, extraction of gasoline from casing-head gas, the efficient production of pools and properties, and the measurement and transportation of natural gas.

Industrial Requirements for the Petroleum Engineer

We often hear that such and such a company wishes to "train their own men." Just what interpretation can we place on this expression? From the experience of the author in industry, it is evident that companies prefer that the colleges instruct the student in the fundamentals only, in so far as it is possible to do so. They prefer to apply the fundamentals to problems in the oil industry in accordance with their own methods. I am quite in sympathy with this procedure. Its strict application to the curriculum of petroleum engineering may make changes desirable. However, if we adopt the expression too literally, training will be turned over to departments teaching the fundamental sciences. This indicates that there is need of application courses, particularly those offering the mathematical approach and drawing on fundamentals from all sources. However, too much description should be avoided. It is, of course, necessary to offer an elemental descriptive course of an introductory nature. Thereafter, the work should be truly engineering with the problems drawn freely from production practice. If the teaching of the application of basic sciences to specialized problems is contrary to industry's preference of "training their own men," then similar criticism can be laid at the door of other engineering branches, such as instruction in chemical engineering.

Academic Requirements for Petroleum Engineer

A study of the careers of successful petroleum engineers demonstrates the necessity of aptitude for the work and the development of a personality that will wear well in the business where such a factor is of paramount importance. Much worth-while advice could be given the young student interested in becoming a petroleum

engineer from the aptitude and personality standpoint, with the result that misfits could be profitably directed to more promising fields, to the ultimate benefit of engineering schools, students, and prospective employers. Too few students realize their limitations and too little advice is given students concerning the possibility of their chosen work and the coördination of a program which would be to their ultimate profit.

It has been stated by other engineering educators that the most outstanding academic requirement for the petroleum engineer is a thorough knowledge of English composition, to facilitate proper preparation of technical reports. Considerable difficulty has been recognized in the past because of the inability of engineers to speak or write concisely, clearly and correctly. Technical report writing is an art that many engineers have not conquered, but one of the greatest factors contributing to their advancement. Several years ago, a committee was formed to advise a department of petroleum engineering concerning what should be included in an engineering curriculum. This committee of prominent engineers in various industries made a careful study of curricula, and came to the conclusion that more training was needed in the use of English, particularly in the preparation of written reports. As Professor Walter G. Whitman, of the Massachusetts Institute of Technology, remarked: "The ability to express his views clearly and concisely is of paramount importance to the engineer. To do this he must have a competent grasp of the engineering problem involved and a capacity to so present the problem and his recommendations that others will be convinced of the soundness of his position. These two factors—professional competence and ability for expression—are interrelated and of nearly equivalent significance."

Likewise, the engineer is often handicapped by inadequate capacity for clear-cut speaking, both private and public. Few engineers are able to present a problem to their superiors appropriately. Presentations at technical meetings are equally suggestive of lack of training. If the average engineer, including a considerable portion of the older ones, only realized the relatively small effort necessary for marked improvement in speaking ability, I am sure that the need of this paragraph would not be so pressing.

The importance of the engineering investigation is usually measured by companies in terms of money. From the commercial viewpoint, no project is worthy of recognition unless a profit is reasonably assured. The economic viewpoint is, therefore, of paramount importance. The student should be trained to analyze statistics and facts carefully with proper emphasis on correlation, comparison, and the involved conclusions and recommendations resulting therefrom.

Academic Instruction in Petroleum Engineering

Recognizing the need for versatility on the part of the petroleum engineer and the probability that he will be called upon to meet problems involved in any of the engineering branches, the curricula in petroleum engineering at the various universities and technical schools have been designed to give fundamental training to meet this demand. Separate curricula are now offered by approximately twelve institutions in the United States.

Faculties

The original faculties in these schools were recruited largely from the other branches of engineering, particularly those who had a practical understanding of geology in relation to production problems. However, the graduates in petroleum engineering, particularly those who have had graduate work and practical experience in the oil and gas industry, are being included in increasing numbers. A well balanced faculty should be such that practical experience on the one hand and research experience on the other hand are duly represented.

Entrance Requirements and General Course of Study

Entrance qualifications are essentially those required by the other engineering branches with emphasis placed upon mathematics, physics and chemistry.

Ordinarily, the first two years of the engineering course are devoted to basic fundamentals with specialization during the last two years of the four year course of study. Attempts have been made to extend the four year course to five or six years. However, the four year course predominates at this time with some inclination towards the five year program. The ramifications of the oil business demands such versatility on the part of the young engineer that it is extremely difficult to provide all necessary fundamentals in the four year course of study.

Vacation Courses and Coöperative Plans

Most schools of petroleum engineering recommend as much practical experience as possible to be gained during the summer vacations. In one instance a coöperative plan with industry permits the students to alternate each three months between attendance in the class room and working in the oil fields. It is desirable to institute a summer field course for the benefit of those students not securing vacation employment. Such a course was given by the University of Texas for credit. Not only were the problems incident to drilling, production, transportation, and storage studied,

but the students lived in oil field camps and had an opportunity to observe and become acquainted with oil field employees—a most essential part of their education. Such experience is of particular value in facilitating a decision on the part of the young engineer as to whether or not he is fitted by aptitude for the work.

Basic Courses

Examination of the curricula offered in petroleum engineering throughout the United States reveals that considerable stress is placed upon the fundamental courses in mathematics, chemistry, physics, drawing, and English. Mathematics usually includes algebra, trigonometry, analytical geometry, and differential and integral calculus. Courses in chemistry include: general inorganic chemistry, qualitative and quantitative analysis, organic chemistry, and physical chemistry. Courses in physics usually include mechanics, electricity and magnetism, sound, light and heat. Considerable emphasis is placed on the courses in English, particularly those giving fundamental training in technical report writing. Plane surveying, theoretical and applied mechanics, and hydraulics are usually studied by the petroleum engineering student in the department of civil engineering. Courses in geology include general geology, mineralogy, petrography, structural geology, and field methods. General courses in applied thermodynamics, prime movers, foundry, and machine shop, may be offered in the departments of mechanical engineering. A short course in alternating and direct current machinery is usually offered in the departments of electrical engineering.

Applied Courses

The specialized courses in petroleum engineering generally include an introductory course which surveys the petroleum industry. This is followed by a descriptive course covering oil field development and production methods. A laboratory course generally parallels the descriptive course. Finally, a specialized course is offered in oil field engineering with an auxiliary course devoted to design and detailed problems. Most schools of petroleum engineering offer courses in metering, transportation and utilization of natural gas and its products. The economical phases of the petroleum industry may be studied in special courses in management and valuation of oil properties, with some attention being given to the study of oil field accounting methods. The examination of cores and the determination of saturation, permeability, and other characteristics of reservoir rocks, is now considered routine in the laboratory courses.

Hence, it is apparent that the so-called "descriptive" courses offered in the specialized subjects should give way in a large measure to training in the application of fundamental principles to production engineering. For example, training in core analysis, permeability, flow of oil-gas mixtures through sand, gas flow, metering, distillation, and fundamentals of reservoir performance, are as basic to the petroleum engineer as mechanical separation, filtering, and drying are to the chemical engineer. A senior course and text for petroleum engineers might profitably be organized which would serve the same purpose as the senior course in chemical engineering does to the chemical engineer. Such a course would entail only sufficient description to tie the various chapters together, but would in no sense be construed as training in any particular company's methods, and might well be construed as "fundamental." Fortunately, considerable thought is being given such matters in the petroleum engineering departments to-day.

Graduate Work

Ordinarily, the first, or B.S. degree, in petroleum engineering is designed to fit the students for commercial positions. Graduate work leading to the M.S. degree may help secure positions in research, both private and institutional. Preference is occasionally shown students with advanced degrees by some of the producing companies in view of the broader training in fundamentals and research methods. The better students should be encouraged to take graduate work, and might be rewarded for so-doing by a preferential choice of commercial positions open.

Advanced and Special Courses

More attention should be directed to the mathematical approach in the study of petroleum engineering problems. Ordinarily, calculus is finished in the sophomore year, and becomes a part of the dim past to some of the senior students. Advanced studies such as differential equations, graphical analysis, etc., should maintain the student's interest in mathematics and help in the solution of practical problems. A junior or senior engineering course is often considered as "hard," depending upon the stress placed on mathematics. Alignment charts, the use of logarithmic paper, and the plotting of test and operational results are seeemingly simple, but students sometimes experience difficulty with elemental concepts if they are not used often enough. It is evident that courses in prime movers, and alternating and direct current machinery, should be offered to the petroleum engineer. The field application is too obvious to warrant further comment.

Too much emphasis cannot be placed upon advanced courses in physics; physical, colloidal, and organic chemistry, especially in connection with graduate work. Advanced work in geology is recommended, including petrographical and paleontological methods as applied to the examination of fragmental particles and drill cuttings. It frequently happens that certain problems may demand the services of specialists, such as the expert petrologist, metallurgist, physical chemist or mathematician. However, the petroleum engineer should have a sufficiently broad training to recognize the need for detailed study by a competent specialist. Also, the application of such detailed investigations or researches to the practical problems at hand are the responsibility of the petroleum engineer.

Advanced practices may be profitably studied from current literature in the graduate courses. These courses should be flexible and adaptable to the newer phases of petroleum technology. A modified seminar for graduate students may also be advisable, provided adequate control is retained on the part of the instructors. Although research work for undergraduates is meritorious in some respects, particularly from the standpoint of research methods, such work is usually included in the graduate schools.

In view of the increasing importance of proration and other matters at least partly controlled by state and national regulatory bodies, it has become necessary for the petroleum engineer to devote increased attention to a study of business law and economics. An understanding of the principles involved in the law of oil and gas is a general requirement of operators and engineers in the petroleum industry. Legal departments work closely with engineering departments. Technical evidence must be prepared in defense of drainage, damage, tax, and other suits at law. Many lawyers have acquired a working knowledge of the more important technical phases of the business. For full coöperation, the engineer should have some training in legal matters. Perhaps his most important function in this respect is in connection with the duties of a technical witness. A knowledge of contracts is of particular value in connection with leasing, drilling, construction or special sub-letting. The engineer employed with smaller organizations may be called upon to participate in these matters in particular, since his duties may cross departmental lines and be broader than would be the case with a large company.

It is obvious that a thorough training in economics is essential for the petroleum engineer. The general course in economics is not sufficient training. The specialized courses should develop the ability to analyze and compare costs. The preparation of estimates of probable profits and the analysis of actual costs involve

many problems in cost accounting. In view of the fact that a majority of engineering reports in commercial practice involve problems in applied economics, this subject is placed second to report writing in relative importance to the engineer.

Petroleum engineers will be called upon to study operating expense sheets and other divisions of the general company books. A short course in accounting is therefore deemed to be of value to the engineer, particularly is he expects to specialize in valuation matters.

The Future of Petroleum Engineering

What of the future of petroleum engineering? The producing industry deals unmistakably with a "wasting asset." Exploratory methods have greatly increased the rate of discovering oil fields. When the flush fields go, secondary methods will be of more importance, but even secondary methods cannot be expected to provide a source of oil indefinitely. However, we do know that substitutes for petroleum will make their appearance in over increasing quantities as petroleum reserves diminish. Will the petroleum engineer of the future be truly a mining engineer, exploiting oil and outcrops, sinking shafts to shallow low cost horizons, developing surface deposits, such as those of Athabasca, and perhaps mining and retorting the immense reserves of oil shale in Colorado and elsewhere? Or will the interests of the coal and petroleum industries eventually merge, and the technique of the petroluem engineer give way to those of the mining engineer, or perhaps the chemical engineer, with his knowledge of polymerization and sythesis? Whatever the future has in store, should we not steer our ship in a course favorable to the welfare of those making a profession of petroleum engineering? Most assuredly we do not want the ship to land "high and dry" with no port in sight. To me, an ever changing and flexible system is indicated for the future. The need for emphasis of fundamentals is of paramount importance. By concerted action, top-heavy enrollments should be reduced and kept within justifiable bounds. This statement may be extended reasonably to all branches of engineering. We should emphasize that the demand is principally for better than average men. If we can teach our students to be versatile and capable of coping with the changing order of events of the future, we will have kept our trust with youth, and, of no less importance, our trust with our own selves.

THE GEOLOGICAL ENGINEERING PROBLEM *

By G. M. BUTLER

Dean, College of Mines and Engineering, University of Arizona

Introductory

Last year the E. C. P. D. Committee on Engineering Schools was requested to investigate for accrediting a number of curricula in geological engineering or engineering geology, and, also, several geological options of mining or petroleum engineering curricula. Since your speaker is a geologist and represents the A. I. M. E. on this Committee, it devolved largely on him to try to determine whether such curricula are truly engineering in nature and should be considered by the Committee. Correspondence and personal conferences with many geologists and mining engineers elicted such a variety of opinions that it was impossible to reach a conclusion that would be generally acceptable. Consequently, it was thought best to recommend few such curricula for accrediting and to give further consideration to the problem before deciding definitely about the status of such courses. Although a great deal of thought was given to the matter, it is the personal opinion of your speaker that it is possible that none of them should have been accredited until the problem had been more thoroughly considered. It is hoped that, as a result of the discussions to which we shall listen here, some satisfactory decision may be reached.

Satisfactory Engineering Curricula

Your speaker believes that the other members of the Committee, as well as a large majority of other professional engineers, agree that a satisfactory four-year engineering curriculum must comprise the following elements:

1. A strong foundation of work in drawing and descriptive geometry, mathematics, physics, and chemistry must be laid down during the first two years. Courses in shop practice and surveying should, also, be included in some curricula.

2. During the last two years a super-structure must be erected on this foundation. In other words, a considerable proportion of the courses required then must be of such a nature that they cannot possibly be carried satisfactorily by a student who has not acquired a working knowledge of mathematics, including calculus,

* Presented at the Conference on Mineral Technology at the 46th Annual Meeting, S. P. E. E., College Station, Texas, June 27–30, 1938.

and physics. Among the courses that should be included in the last two years (or, in some instances, even earlier if the entrance requirements are such as to permit it) are analytical mechanics, strength of materials, thermodynamics, and hydraulics. Many engineers would also include elements of structural or machine design and electrical engineering. There appears to exist no general agreement as what proportion of the work of the last two years should consist of such courses.

3. It does not matter materially what other courses are required in the last two years as long as the conditions already set forth are met and as long as the work has a definite engineering objective. These courses will naturally vary with the branch of engineering that the student plans to follow and many of them will normally be closely related thereto.

Persons who accept as true the statements made in the three preceding paragraphs contend that engineering is a quantitative, mathematical profession and that no curriculum can justly be called engineering unless it conforms to these minimum requirements. Conversely they admit that any curriculum that does not conform to these requirements may be styled engineering. If all engineers agreed that the minimum standards set forth are proper and desirable ones, the problem would not be hard to solve, but, unfortunately, a considerable proportion of the mining engineers, at least, positively refuse to admit that it is necessary to build upon the mathematical and physical foundation laid in the first two years if a curriculum deserves to be called engineering.

Director Wm. R. Chedsey, of the Missouri School of Mines and Metallurgy, wrote on May 12th of this year as follows:

> It seems to me there is getting to be quite a divergence of opinion as to an engineer's function or the definition of an engineer. For the past twenty years I have been calling one who does work in which mathematics and physics are applied a technologist and have been reserving the term "engineer" for one who economically applies such work. That is, my definition of an engineer is one who economically puts to work the findings of science. Of course, it is my impression that to do this he must know his mathematics and physics, and, because I am interested in the mineral industries, naturally I include chemistry.

Herbert Hoover in his book entitled "Principles of Mining" says:

> Engineering sense is that fine blend of honesty, ingenuity, and intuition which is a mental endowment apart from knowledge and experience. Its possession is the test of the real engineer.

I doubt if any of us are disposed to question the validity of most of these statements although I do not believe that Director

Chedsey would insist that anyone who puts to work the findings of science is an engineer if he recollects that, if this definition is correct, all Doctors of Medicines are engineers.

Graduates of four-year engineering courses are admittedly not engineers. They have presumably received technological training that will enable them to become engineers after they have gained the requisite experience and if they possess some degree of honesty, ingenuity, and intuition.

The point at issue is the amount of technological training that they should receive. Some persons apparently believe that approximately two years is sufficient; others, and they constitute a large majority, say that more such training is essential and refuse to admit that any curriculum that includes only about two years of this technological training should or can properly be styled an engineering curriculum. This question of the amount of theoretical and applied mathematics and physics that must be included in an engineering curriculum is the crux of the problem, but there is at least one other question to be settled.

What is Geological Engineering?

If you should ask several competent instructors of electrical engineering, as an illustration, to outline satisfactory electrical engineering curricula, the results would differ only in detail; some would include more and some less of the humanities; some would allot more units to a certain subject and some less; some would leave out certain courses that others considered desirable; but the general pattern would be the same. Now what is the situation as regards geological engineering? Suppose we cite some examples.

In the last two years of the curriculum offered at the Colorado School of Mines that leads to the degree of Geological Engineer, courses in physical chemistry, strength of materials, kinematics of machinery, thermodynamics, electrical engineering, engineering design, and elementary and advanced geophysics are required although some of these courses might be criticized as too brief. These subjects, which all have freshmen and sophomore mathematics and physics as prerequisites, make up 29 per cent of the work of the junior and senior years.

Besides courses in industrial organization, principles of economics, engineering English, contracts and specifications, advanced physics, interpretation of maps, and ten units of electives (which constitute 31 per cent of the work required in the last two years), the other required courses are all geological and they constitute 40 per cent of the work of the junior and senior years. With the exception of mineral land and mine surveying, there is not a single mining course and no metallurgy or ore dressing in the curriculum.

Now let us consider the nature of the last two years of the geological engineering courses offered at the Montana School of Mines. Fifteen per cent of that curriculum is made up of physical chemistry, analytical mechanics, and hydraulics, 42 per cent of geological subjects, and 16 per cent may be called miscellaneous, but in addition, mining, metallurgical, and ore dressing courses constitute 27 per cent of the curriculum.

Lastly, suppose we consider the character of the junior and senior years of the geological engineering curriculum that contains the petroleum engineering sequence of courses that is offered at the institute "X."

It contains no advanced engineering subjects whatever—no analytical mechanics, no strength of materials, no hydraulics, no electrical engineering, and no thermodynamics. Fifty-three per cent of the work of the last two years is in geological subjects, 20 per cent in petroleum technology, and 27 per cent in miscellaneous subjects and electives.

Nearly all of the curricula in geological engineering offered in this country are more or less similar to one of the three just described.

The Colorado School of Mines course might be considered geological engineering proper, if there is such a branch of engineering. The Montana School of Mines course should probably be considered an option of a mining engineering curriculum, and institution "X" course is apparently of the type that should be regarded as an option of a petroleum engineering curriculum although woefully weak in engineering subjects. The table that follows will make very clear the fundamental differences between the last two years of these three curricula:

	Colorado	Montana	"X"
Advanced engineering subjects generally recognized as acceptable	29%	15%	—
Geological subjects	40%	42%	53%
Mining engineering, metallurgy, and ore dressing courses	—	27%	—
Petroleum or technological engineering subjects	—	—	20%
Miscellaneous	31%	16%	27%

There is certainly more real difference between the last two years of these three curricula than there is between the last two years of nearly all mechanical and electrical engineering curricula. It is undeniable, then, that there is no unanimity of opinion about what a geological engineering student should study. There cannot, therefore, be any general agreement as to just what a geological engineer is or should be.

Probably some of you may wonder why the curriculum offered at the Montana School of Mines was accredited when only 15 per cent of the work of the last two years consists of advanced general engineering subjects that are recognized as acceptable. That proportion is certainly very small and may be altogether too small even if larger than in many similar curricula. The reason is found in the 27 per cent of required courses in mining engineering, metallurgy, and ore dressing.

If you ask how much advanced mathematics and physics are employed in these courses, your speaker can only confess ignorance. He did not inspect them. It is an undeniable fact, however, that many such courses are largely or entirely descriptive and not quantitative. Mathematics and physics can be applied in some of these courses and they doubtless are so applied in some institutions, but the degree of possible application is certainly much less than in acceptable civil, electrical, and mechanical engineering courses.

Whether such a curriculum, which as stated is essentially a geological option of a mining engineering course, should or should not be accredited depends upon the character of the mining course and the proportion of other subjects that involve a knowledge of advanced mathematics and physics that we are going to demand in the last two years. That some minimum proportion must be required is the conviction of most engineers who have been consulted.

Professor Thos. T. Read of Columbia University wrote as follows to Director Chedsey on April 27th of this year:

> They (the members of the Committee on Engineering Schools) were set up to accredit engineering curricula and held firmly to the belief that a curriculum called engineering, of whatever specialty, must have a minimum content of engineering in it.—What we need is to get a more general agreement than exists at present on the minimum content of an engineering curriculum, and more specifically on the minimum engineering content of the curricula called either geological engineering or engineering geology.—My own idea is that a man is not an engineer unless he can design whatever his field calls for.

Some General Remarks

Your speaker is convinced that the words "engineer" and "engineering" have been used far too indiscriminately. Board of Engineering Registration must frequently prevent plumbers from calling themselves "Sanitary Engineers," nurserymen from using the title "Landscape Engineers," etc. Apparently some educators have adopted this unfortunate and undesirable practice. Certainly the members of the Committee on Engineering Schools are unanimous in believing that some of the curricula offered for accredit-

ing are not engineering and should never have been called engineering, and your speaker is not now referring to geological engineering curricula. He does strongly deplore the tendency to misuse the title of our profession and believes that, if this profession is ever to gain the public recognition that it deserves, this debasement of its name must cease. He is, also, hopeful that due consideration of the problem and its implications will cause the gentlemen who now administer some courses that are now called geological engineering or some similar title to re-name them and thus to uphold the dignity and solidarity of the profession of engineering.

It has been claimed that some of the geological engineering courses are properly named because they train men for just as important a part in the development of our mineral industries as do mining engineering courses. Any reasonable man will readily admit that it is an important part of mineral industries' education to train persons to locate deposits of valuable substances that are hidden within the earth, but there seems to be absolutely no necessity or reason why such persons should be called engineers. "Geologists" would certainly seem to be an entirely proper and adequate term for them no matter whether they have or have not studied calculus.

As a geologist, your speaker is forced to admit that geology is not engineering and is not even an exact, mathematical science. He is aware of the fact that calculus and advanced physics are used by research workers in attempting to solve some of its problems, but he ventures to claim that there are few if any geological courses taught to juniors or seniors in this country that cannot be handled creditably by a student who knows no mathematics beyond trigonometry.

As for physics, a student must, of course, have some knowledge of the laws of light before he can profitably study micro-mineralogy, but the few necessary laws are almost invariably taught as an introduction to such a course.

Frankly, your speaker seriously questions the desirability of requiring students of such curricula as that offered at Institution "X" to study analytical geometry and calculus. He doubts if any of the graduates of such courses ever use the knowledge of higher mathematics gained, and he is strongly inclined to believe that the time devoted to these subjects might better be used for some other purpose, such as for more training in the humanities.

Of course, many engineering graduates never use analytical geometry or calculus, and that is particularly true of mining engineers, but a considerable proportion of them *do* make use of their training in these subjects, and none of them can be sure as a student that he will not need that knowledge, so it must be im-

parted to all of them. As engineering advances, thorough training in mathematics and physics becomes increasingly necessary.

It seems hardly necessary to point out that good courses in electrical, gravitational, and seismic geophysics demand a thorough knowledge of advanced mathematics and physics and are as truly engineering applications of these subjects as is electronics. This fact must be kept in mind when evaluating geological engineering courses.

Finally, it must be clearly understood that the Committee has never ventured to question the desirability and usefulness of any curriculum that it has refused to accredit. An unaccredited curriculum may prepare the students who take it to meet a real demand; the mineral industries may absorb its graduates in large numbers; it may be highly desirable to continue to offer it; but the adverse decision was reached because the Committee was convinced that the curriculum was deficient in engineering content and should not be labeled engineering. It must be remembered, further, that failure to accredit may have been based on other factors than course content. It is very doubtful whether anything said here will cause the members of the Committee to adopt a different attitude. Our task would seem to be to try to reach some agreement as to approximately the minimum of work that the majority of engineers believe to be truly engineering in nature that must be required in the last two years of a course in order to make it an engineering curriculum, and then to try to obtain general acceptance of the minimum standards thus set up. If we can reach an agreement that will be satisfactory to the members of the Committee and the majority of engineers, it will then be necessary for us to see that our curricula conform to these minimum requirements, or, if it seems undesirable to us to do that, to cease to call these courses enginering curricula.

Discussion

Thomas T. Reed, Columbia University (written discussion): Some of the misunderstanding over the accrediting of geological curricula in engineering schools can justly be attributed to State Licensing Boards which, in some cases at least, do not seem to understand clearly the distinction between geological work and engineering work. I know of one case where a geologist working for a municipal water supply project was required to secure a license as a professional engineer in that State, though he was not an engineer and did not claim to be one. Obviously there is no more reason why a geologist doing consulting work in connection with an engineering project should be required to register as a professional engineer than there is for requiring a doctor of medicine to register as a professional engineer in order to give con-

sulting advice on the health aspects of a water-supply project. It is not only illogical, but it discredits the licensing system, for one wonders how a geologist who does not claim to be an engineer could obtain a license as one.

Some of the misunderstanding derives, however, from the gradual development of geological instruction, some of it along lines closely affiliated with engineering and some of it with no relation to engineering. My own University, for example, had no professor of geology before its School of Mines was established, and for a long time all the geology taught here was that in the School of Mines. With the gradual growth of the geology department it continually expanded in the field of pure science. The great majority of the students who now take work, undergraduate or graduate, in the geology department are interested in geology as a pure science. Such great geological fields as paleontology and physiography have almost no connection with engineering; what little they have might be described as a consulting relationship. One might say, indeed, that geology as a whole is merely a basic science for engineering, and only a relatively small part of the science has any application in engineering work.

In those schools where engineering students who have had a minimum requirement of basic engineering instruction are allowed to major in geology (in its applications to engineering) in their senior year it is proper that the B.S. degree which they receive on the completion of their course should be recognized as an engineering degree. But where the student has pursued a general B.S. course, merely specializing in the application of geology to engineering, without having taken all the basic requirements of an engineering course he should not expect recognition as an engineer. The former is a geological engineer, the latter an engineering geologist. The distinction between them should be as plain as that between buttered toast and toasted butter.

It is natural that any geology department in an engineering school should seek to develop its work in the field of pure science. But a curriculum offered covering that part of the science which is applicable to problems that arise in engineering work is not an engineering curriculum, and should not be so accredited, unless it also contains the basic minimum requirements of an engineering curriculum.

Frank F. Grout: This paper covers two matters that may well be further elaborated, (1) the definitions of engineering and technology, and (2) the content of the last two years of a college course which may properly lead to a degree of Bachelor in Engineering.

(1) The discussion of definitions is a dangerous one, as it is likely to degenerate into quibbling and lead to no end. By appeal

to a dictionary one may find a basis for objection to certain phrases in Dean Butler's remarks, but as a matter of fact the dictionary no doubt includes popular usage rather than strict technical usage; and no better basis is likely to be found for strict technical usage than the opinion of some committee of engineers. Granting all this, it is noteworthy that Dean Butler refers to the four year courses in most of our engineering colleges as giving only "technological" training which may enable the students to become engineers in later years. If that is true the courses in the sciences may be just as truly technological as those particular courses listed by Dean Butler, mechanics, strength of materials, thermodynamics, hydraulics, and machine design. Technology is defined as "industrial science" with examples including the important industries, spinning, weaving, metallurgy, brewing. Clearly under the head of industrial science are the courses in economic geology, applied petrography, ore deposits, metallurgy, metallography, petroleum engineering, and others which Dean Butler questions. Clearly also a man who has such technological training in sciences may in a few years become such an engineer as specified in Dean Butler's quotation from Prof. T. T. Read—one who "can design whatever his field calls for."

(2) The other problem is that of specifying a minimum of courses based on prerequisite calculus and physics, to be required in all courses accredited as suitable for a degree of Bachelor of Engineering. Probably the courses in mechanics, strength of materials, thermodynamics, and machine design may be approved by a large majority of engineers. Hydraulics and electrical engineering are more specialized and might well be made optional with other special lines of engineering.

More important than the matter of actual selection are the questions of decision, and of administration of the decision. Possibly the E. C. P. D. should take time to study the matter and decide what courses and how many hours constitute a minimum; possibly it should be the S. P. E. E. itself; but I am quite certain that authority in such matters should not be delegated to a small committee composed of members each of whom has probably a specialized field and point of view. If a committee studies it, they should report to the larger group for decision before applying the decision.

And again, the decision as to whether or not a curriculum conforms to the minimum requirements, should not be made wholly on the names of courses offered; but in cases of doubt the men who teach the courses should be given a hearing before adverse decisions are made. It may be that this will make the administration of the ruling almost impossible, but whether it is or not, those who make the decisions should realize that no other way is fair and just.

UNDERGRADUATE THESES AS A MEANS OF DEVELOPING RESEARCH INITIATIVE AMONG FACULTY AND STUDENTS *

By WARREN RAEDER

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The undergraduate thesis presents an opportunity for developing research initiative in a student which exists in scarcely any other part of his curriculum. The nature of practically all of his other work is such that a true research attitude is rarely stimulated. I am using the term "research" in the sense that it implies delving into a study of phenomena, the exact nature of which has not yet been so thoroughly established that, like accepted laws of physics and chemistry, they are readily available in text-books or other engineering literature.

From this point of view the undergraduate curriculum does not stimulate research initiative because the student's work is prescribed for him. His plates in mechanical drawing, his subject matter and problems assigned in mechanics and mathematics, even the problems of design of structures in his senior year are all determined by others. To use a popular and much abused term, he may be said to be regimented along avenues of learning which experienced teachers believe will give him the best engineering education in the allotted time of four years.

The undergraduate thesis, then, becomes his big opportunity to do something on his own responsibility. Here it is necessary for him to visualize his problem, define its limits, collect his data diligently and accurately and from them draw a logical conclusion. He must, finally, present his work in an orderly and approved scientific manner. And he must do these things to a great extent on his own initiative.

At the University of California some years ago the question arose in the Civil Engineering department of abandoning the undergraduate thesis. To get the views of former students themselves, numerous practicing engineering alumni were contacted. Almost without exception the answer was that the thesis should be retained. The strongest argument of these engineers was that the thesis offered the student his best opportunity to use his in-

* Presented at Joint Conference on Engineering Research, Civil Engineering, and Mechanics, S. P. E. E., College Station, Texas, June 28, 1938.

itiative and solve his problem according to his own ideas. There is a "thrill" in the achievement of an objective of this kind which a student needs. It is probably more important to experience this thrill than to experience the satisfaction of receiving a good grade in one more prescribed course.

These remarks are not meant to imply that all undergraduate students should be required to write a thesis. There are several factors which would seem to rule against such a program. Not all students are temperamentally fitted to gain the benefits that should accrue from the time and effort involved; moreover, if the research is carried out in the laboratory, then the additional cost and inconvenience of using or tying up physical equipment are factors to be considered. After all the degree of the "development of research initiative" varies with the students' personal response and there is little point to ringing a door bell when there is no one at home.

The student, of course, does get the opportunity of testing research procedure in his laboratory courses where he is left to his own devices, at least to a limited extent, in demonstrating certain physical facts or in working out designs of structures. Such opportunity occurs in courses in physics, chemistry, materials testing and in design. Although not true research such work may be sufficient to develop a spirit of "diligent and protracted inquiry" in students who could not benefit adequately from more intense research problems.

At the University of Colorado the requirement of a thesis was dropped from the curriculum many years ago. At the present time, the four major engineering branches, civil, electrical, mechanical, and chemical, have student chapters of their national societies and at their meetings (or in a seminar course) students present one or more papers on subjects which they may choose themselves. The presentation of these reports offers some opportunity for that development of initiative and originality which the thesis contemplates.

I have no illusions about the intrinsic merit of research carried on by undergraduate students. Perhaps, as never before, research to be of value requires not only adaptability and enthusiasm but a thorough knowledge of the field up to its present limits. How can we expect a student with three or three and one-half years of undergraduate work to delve into uncharted fields and uncover new truths?

Nevertheless the experience of the University of Colorado is interesting. The department of Electrical Engineering offers seniors a two-hour laboratory course called "Experimental Electrical Engineering." This appears in the catalog as an elective, possibly

because the instructor elects those seniors who in his opinion have the proper qualifications to handle the work expected of them. During the years 1931 to 1935 papers of students enrolled in this course which were submitted in the national student contest supervised by the American Institute of Electrical Engineers received four first prizes, one second, and one honorable mention. A paper entered in this contest is judged (along with other items) 30 per cent for "value in its field" and 30 per cent for "value to electrical engineering." Many of these papers were published in the *Journal* of the A. I. E. E.

Of course, to attain such results or in general, to make undergraduate theses at all worth while it is necessary that they have close faculty supervision. In the instance of the electrical engineering papers mentioned above, two students usually worked together on a problem and in only one case were they turned loose without rather close supervision.

The teacher under whose guidance the work is being done must furnish the necessary background, suggest the limits of the problem and, in general, exercise that supervision which will bring good results without undue loss of time and effort. This is, however, time-consuming for the faculty. At a university where an instructor has a teaching load of from twelve to seventeen hours, obviously it is physically impossible for him to supervise even two or three theses adequately. This factor of the additional burden on the faculty is of major importance since under such circumstances either the teaching or the theses will suffer. I suspect that one reason for the elimination of the theses from curricula is the fact that teaching staffs could not properly administer them.

The above discussion considers the value of the thesis as an incentive to research among students. What about the faculty? In the case of those members of the faculty who are interested in research and engage in it there is no need for a stimulus. For such workers, student research can be of great assistance in reconnaissance, establishing boundaries of a problem and sometimes in the major investigation itself.

For that larger group not engaged in research, the undergraduate thesis may frequently furnish that tangible incentive needed to initiate a program of investigation. For the young teacher some research, of course, is very desirable. For the more mature man laboratory work tends to encourage alertness, greater sympathy for and receptivity to new ideas and developments. A teacher must in some way build up a resistance to the growth of mental silicosis. Research offers such an opportunity.

THE UNDERGRADUATE THESIS AND RESEARCH *

By GEORGE C. ERNST

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This paper is a brief perspective of (*a*) the undergraduate thesis, and (*b*) engineering research in educational institutions.

The Undergraduate Thesis

Papers and discussions † from 1893 through 1913 in the *Proceedings* of the Society reveal that the majority of engineering educators felt the undergraduate thesis to be an essential portion of the curriculum. Such papers were rather frequent from 1893 to 1901 with renewed interest shown in 1912 and 1913, although the effectiveness of the undergraduate thesis was questioned by some. Since 1913 no marked interest in discussing the subject has been apparent through the medium of the proceedings. It seems justified, therefore, to obtain an estimate of the number of institutions offering the undergraduate thesis at the present time. Such an estimate should indicate the proportion likely to be interested in the use of research in this connection.

In order to obtain the information desired, the 1937–1938 catalogues which were available for 122 United States institutions ‡ were reviewed for the purpose of separating the curriculums in civil, mechanical, electrical, and chemical engineering,§ into those in which the undergraduate thesis was (*a*) required, (*b*) elective, (*c*) elective with special consent of the dean or department head, and (*d*) not offered. The results were tabulated with respect to (*a*) senior enrollment (not separated into the various departments) 1937–1938, ‖ (*b*) type of financial support (private, public, denominational),¶ and (*c*) accrediting by regional associations.**

* Presented at Joint Conference on Engineering Research, Civil Engineering, and Mechanics, S. P. E. E., College Station, Texas, June 27–30, 1938.

† Papers and discussions on the subject are listed in the bibliography.

‡ The institutions were taken from those listed in the JOURNAL for December, 1937, pp. 341–347.

§ 47 of the 122 institutions did not have uniform requirements for all departments.

‖ See footnote ‡.

¶ This information was obtained from the Educational Directory of the United States Department of Interior, Part II, Bulletin 1937, No. 1.

** See footnote ¶.

While recognizing the danger of attempting to draw conclusions from such a tabulation, the results seem to show several rather definite indications. Certainly no marked difference is shown by the size of institution (Table 1), if it is assumed that those having an excess of 300 seniors are too few to be representative. The tabulation also indicates that the greater number of departments have omitted the thesis from undergraduate work. The ratio of those not offering to those requiring (approximately equal to 2) is about the same for civil, mechanical, and electrical, but is not as high for chemical. Out of a total of 334 departments definitely committed to one side or the other, 220 did not offer thesis work, while 114 required it.

TABLE 1

SIZE OF INSTITUTION AND THESIS REQUIREMENTS

Senior Thesis Requirement as stated in 1937–1938 catalog	C.E.						M.E.						E.E.						Ch.E.					
	Institutions grouped according to total senior enrollment in the ranges shown																							
	0–100	101–200	201–300	301–400	401–500	Totals	0–100	101–200	201–300	301–400	401–500	Totals	0–100	101–200	201–300	301–400	401–500	Totals	0–100	101–200	201–300	301–400	401–500	Totals
Not offered	40	13	6	0	1	60	41	12	5	0	1	59	39	14	6	1	1	61	23	12	5	0	0	40
Elective with special consent	6	2	0	0	0	8	5	2	0	0	0	7	4	3	0	0	0	7	4	2	0	0	0	6
Elective	12	6	2	1	0	21	10	5	2	2	0	19	12	5	3	1	0	21	7	2	1	2	0	12
Required	19	6	2	3	1	31	14	8	3	2	1	28	17	4	1	2	1	25	15	8	4	1	2	30
						120						113						114						88

TABLE 2

TYPE OF FINANCIAL SUPPORT VS. THESIS REQUIREMENTS

Senior Thesis Requirement as stated in 1937–1938 catalog	C.E.					M.E.					E.E.					Ch.E.				
	Institutions grouped according to type of financial support shown																			
	Public	Public & Private	Private	Denom. Terr.	Totals	Public	Public & Private	Private	Denom. Terr.	Totals	Public	Public & Private	Private	Denom. Terr.	Totals	Public	Public & Private	Private	Denom. Terr.	Totals
Not offered	36	1	15	7	1	60	33	1	16	8	1	59	35	1	15	10	0	61	23	1	10	6	0	40
Elective with special consent	5	0	2	1	0	8	4	0	2	1	0	7	3	0	3	1	0	7	3	0	3	0	0	6
Elective	12	2	6	1	0	21	13	2	3	1	0	19	14	2	5	0	0	21	10	0	2	0	0	12
Required	14	0	11	6	0	31	13	0	11	4	0	28	11	0	10	4	0	25	15	0	13	2	0	30
						120						113						114						88

In the public institutions (Table 2) approximately 30 per cent of the departments require the thesis as compared with 45 per cent for the private institutions. Similarly, the regional classification (Table 3) shows the following percentages requiring the

TABLE 3

REGIONAL ACCREDITING VS. THESIS REQUIREMENTS

Senior Thesis Requirement as stated in 1937–1938 catalog	C.E.						M.E.						E.E.						Ch.E.					
	Institutions grouped according to regional accrediting as shown																							
	New England	Middle States	North Central	Southern	Northwest	Totals	New England	Middle States	North Central	Southern	Northwest	Totals	New England	Middle States	North Central	Southern	Northwest	Totals	New England	Middle States	North Central	Southern	Northwest	Totals
Not offered.....	2	11	21	14	1	49	3	12	21	15	1	52	3	8	22	18	1	52	1	9	14	11	2	37
Elective with special consent	1	1	3	2	0	7	0	1	4	1	0	6	0	2	3	1	0	6	0	1	3	1	0	5
Elective.....	3	5	9	1	1	19	3	4	9	1	2	19	2	5	8	1	3	19	2	1	7	1	1	12
Required.....	2	9	8	7	2	28	1	9	9	3	4	26	2	10	8	2	2	24	2	11	10	3	4	30
						103						103						101						84

Note: All Institutions tabulated in Table 1 and 2 are not accredited by regional associations.

thesis in the various sections, Southern—21 per cent, North Central—31 per cent, New England—45 per cent, Middle States—49 per cent, and Northwest—71 per cent.

It is to be noted that in the new department of chemical engineering the number requiring the thesis exceed those not offering it in the private institutions and in the New England, Middle States, and Northwest regional groups.

Such then is the present status of the undergraduate thesis, with 114 departments definitely requiring it out of the total of 435 which were investigated.

ENGINEERING RESEARCH

The early (1893–1904) attitude toward undergraduate research was quite different from that of the thesis, at least as recorded in the Proceedings of the Society. While the thesis was practically a universal feature of the curriculum, opinion as to the value of undergraduate research appeared to be equally divided up to 1904. The Proceedings do not offer material particularly pertinent to the subject from 1904 through 1915. A revival of interest in research was apparent about 1916 followed by an increasing recognition of its value up to the present time. Outstanding papers on the function, organization, and value of engineering research are those of A

N. Talbot, University of Illinois, in 1904 and 1932, A. E. White, University of Michigan, in 1920 and 1931, and the Report on Engineering Research made in 1935.

The stand taken since 1916 has been clearly and definitely toward the improvement of the personnel, equipment, and organization of engineering research. At no time does there appear to be a desire, on the part of those intimately acquainted with the problems of institutional research, to use the undergraduate excepting when necessary due to lack of other facilities.

Many institutions do an unusually creditable job in developing the "method of research" and the facility for "original thinking" on the part of the undergraduate by means of properly conducted professional seminars combined with courses in technical or report writing. The seminars review and discuss current magazines, past researches, and research methods while the course in report writing develops the proper method of report or thesis organization. It must be recognized, of course, that such an arrangement must be handled by an experienced instructor having a thorough knowledge of engineering literature.

With regard to the effect of research upon the staff member it has been generally admitted that much is gained, both in spirit and knowledge, providing there is sufficient (*a*) time, (*b*) money, (*c*) personal desire, and (*d*) previous research training.

Summary

In summarizing, it appears that, (1) a minority would be concerned with the problem of undergraduate research, (2) for improvement of institutional research, the use of undergraduates should be definitely discouraged, and (3) for the improvement of the undergraduate, adequate courses can be made to supply the function of research.

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ON ENCOURAGING YOUNG INSTRUCTORS TO DO RESEARCH WORK IN MECHANICS *

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This topic was assigned to your speaker in the form of the question: "Should Teachers of Mechanics be Encouraged to Develop a Genuine and Absorbing Research Interest?" Stated in this form there is no unequivocal answer, like "yes" or "no," so much being dependent upon the temperament and talents of the individual.

Let us assume now that we are discussing the real teacher of mechanics, that is, the one who is effective because of his interest in the subject, and who is inspired and inspiring because of his belief in the enduring value of a mastery of the elements of this subject by his students. This phrase may strike some of you as being merely a pleasant platitude, but few of you will have to search your memories very carefully to recall the students who took mechanics more or less under protest as one of the many things necessary to be endured to reach the goal of graduation in engineering. This is the sort of student who can often be re-awakened by a really effective teacher of mechanics, made to see the beauty and simplicity of the underlying principles, and generally imbued with a new intellectual curiosity. He can then be held to a decent standard of accomplishment and led to a more objective viewpoint regarding his own successes and failures.

There are in general three reasons why a teacher should engage in research:

(*a*) The possibility that he may add a small but valuable contribution to the knowledge of his field.
(*b*) The possibility that he may make himself better known and recognized in the field and thus advance himself in rank and pay.
(*c*) For the good of his soul.

It requires only a rudimentary conception of ethics to make it apparent that the second of these, while not inherently bad, does not quite rank with the other two in praiseworthiness.

* Presented at Joint Conference on Engineering Research, Civil Engineering, and Mechanics, S. P. E. E., College Station, Texas, June 27–30, 1938.

If any one of us managed to get through his undergraduate career without having taken a course under some instructor who was so totally wrapped up in research that he had no time to prepare for a clear, accurate and interesting presentation of his subject to his classes, he may indeed count himself fortunate. When an instructor is found to be in this particular habit of mind, the chances are rather large that he is motivated by this second reason for research. I would here commend a reading or a rereading of the excellent short article by A. J. McGaw in the April, 1938, issue of the JOURNAL on "Teaching Versus Research." In this article the case against an all-absorbing interest in research is clearly stated and ably argued, and with this let us pass over reason (*b*) as being outside the scope of the present discussion.

Reason (*a*) is, on all counts, a good and commendable one. What a fine world it would be if everyone who lived in it left at least one shining jewel of additional knowledge to be passed on to posterity. On the other hand, what a master mind it would require to know and appreciate all the jewels! Nevertheless, there is always this hope and possibility, and it is by just such small contributions that our structure of science has been built up. It is not now so urgent a motive as it once was. The boundary line of knowledge is farther out, it takes longer to reach it, and the line of supply becomes more tenuous. But it is still within reason that every teacher of mechanics can reach the front at least in some sector, and take part in the advance. At least, in the effort to reach the front line, the instructor is certain to improve his education and broaden his outlook.

The world has finally become well convinced that research is a valuable, even necessary, factor in our modern economic life. On this point the teachers of science, including mechanics, have definitely won a victory. We have, by this method, given the world things of so much value and met so many pressing needs, that industry and business have begun to support the work even to the extent of moving it into their own houses. We could well rest on our laurels, but I think we shall not do this, but rather turn our attention to things which are a little less pressing and which these new agencies are too likely to overlook. Fortunately, we need no longer press forward in wasteful haste, but may proceed more carefully, leisurely and confidently, so that our work may be more polished and more valuable.

Finally, let us consider reason (*c*). It may be conceivable that an instructor can be so enthusiastic about his work and so interested in his students as promising material for the building of a better world, that he can, with only enough knowledge of his subject to give the undergraduate those elementary things which he

must know, continue to teach without himself becoming useless, stale, unprofitable and uninspiring. I think the probability of anyone's doing this is negligibly small. My memory recalls only one man of this kind, and I think even he, at times, could have been convicted of knowing just a little more than he taught. Simply stated, the thesis is this: If a teacher overdoes research work, he is almost sure to neglect his teaching work and become ineffective. If he neglects his research and study, he becomes an uninspiring and deadening guide for the first stages of the journey, and leaves the student more than willing to stop at the place to which he has been led. For the good of his soul, a teacher, even a born teacher, must develop some interest in research. I should be willing to have him drop it at any stage to turn his hand to some work for practical experience, with the belief that he will always return to research in due time. I have heard it stated as an axiom that once a man ceases to do research work he will never return to it. I believe this is simply not true, although it often turns out that pressure of administrative duties, heavy teaching loads, and too many assignments to committee work delay the fruition of research projects for many years.

Before closing, I should like to suggest some ways of encouraging younger teachers of mechanics to become interested in research. There should always be something, however informal, in every department of mechanics in the nature of a seminar. It may be merely the informal meeting in an office after the day's teaching is over, or after a season of examinations, where the work of the students may be discussed and compared. In addition to bringing out points which lead to better teaching, such discussions can always be led into what is known and what is unknown, and suggestions can be thrown out for further study. Such informal conferences start young teachers thinking. Jam their heads as full as possible with ideas and questions and they will eventually erupt in a desire to find out.

Always there should be some kind of shop available to the teacher for puttering around. The time when research could be done with a tack and a string may have passed, and precision instruments may be the order of the day, but it is still surprising what can be done with two tacks and three strings rigged up in the form of a model. Apparatus is costly, fine apparatus especially so; but most of it is permanent, and a mechanics department can, with time and patience and careful selection, assemble a valuable and useful collection of equipment, which is likely to be an inspiration to the young instructor of the proper bent.

And finally, the department by discussion and interchange of ideas should be kept aware of the promising fields of research. It

is out of the question for a busy teacher to keep up with all the advancing fields, but each member can digest parts of it and discuss it with the others. Statics and dynamics are now classical subjects, and in a certain sense experimenting in them is a waste of time, but research with pencil and paper is still in order. Many problems have not yet been solved, and an experiment, model or otherwise, is the final check of a correct solution. The reduction of some known solution to a more understandable state by simplifications or analogies, puts it in better form for the beginner to grasp, and constitutes a piece of research work more or less valueless under reasons (*a*) or (*b*), but very fine under (*c*).

The whole field of hydraulics is reopened by the modern concepts of fluid dynamics. The mechanics of earth actions, long neglected, has been revived by the work of Terzaghi and his school. This opens up a large field of unsolved problems for research with pencil and paper. The new methods of computing numerical values for indeterminate frameworks are certainly an improvement over the now classical slope-deflection method, but there is hope that still better and simpler methods may be evolved.

The photo-elastic method is now in a state of development where research on the method can be dropped and research with the method begun. With the introduction of "polaroid," a simple and inexpensive photo-elastic outfit has become possible. Standard sets can be bought for as little as $500 or a useful set can be built for $150. All of this adds to the attractiveness of work in mechanics, and should forever prevent the young instructor from turning to poultry husbandry as a hobby.

As a word of caution against the current tendency to employ as new instructors in mechanics only those who have done two or three years of graduate work in the subject, let me say that I would still rate a few years of practical experience in engineering as being worth more than an equal time spent in research work. It tends to fill the young instructor with a wealth of ready examples and illustrations which is the real key to making the student understand the principles.

ENGINEERING HISTORY AS A STIMULUS IN RESEARCH *

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The term research is used here in a broad sense and includes applied as well as fundamental research, if there is any distinction between them. The impulses or motives, the driving forces, which may direct one toward research activity are many but they may be placed in two general groups, external and internal. The *external* impulses are those of a basically coercive character such as an assigned task in an organization with which we are connected, or the feeling that research is the expected, or conventional, thing, that it is the way to advance in our profession. The ultimate goal or aim of such an impulse is the desire for improvement in our social, professional or financial standing. Contrasted with this external pressure are the *internal* motives, such as the desire to achieve, to create, to add to the knowledge of the world, whether we receive financial compensation for it or not. It is this latter impulse, the internal, and the factors which foster and stimulate it, of which I shall particularly speak. I shall try to show how a knowledge of engineering history strengthens this impulse and gives it direction.

Of the individuals moved by this internal impulse or prompting there are those who are natural born investigators, those with original ideas to whom dissecting, analyzing and synthesizing is second nature; activity seems to be an inborn characteristic of these people. Then there is another group, those who strive to emulate, to know and to follow the example of successful people, the imitative. Still others have within themselves abilities and ambitions which if used will be effective in the production and furtherance of ideas,—creators with a philosophical turn of mind. All of these characteristics are found to some extent in all people, and everybody needs some guidance, some direction or some stimulus if they are to realize their possibilities. How does engineering history help to bring this about?

It may be well at the outset to remind you that to most of us the past and the future are romantic periods. The present is ever

* Presented at Conference on Engineering Research, at the 46th Annual Meeting, S. P. E. E., College Station, Texas, June 27–30, 1938.

with us but the past is gowned in the vesture of the oracle and its words are words of wisdom. We have heard much said about the past but the reality of it is just beyond our experience, we reach back for it but cannot quite lay hold on it—we were born too late. We must perforce content ourselves with the *records* of the past and these records are history, in our case engineering history. On the other hand the future is glamorous with expectancy. We never know what a day may bring forth and always hope for the thrill that may come, even though the present is dull and filled with the weariness of details. When the monotony of the present is about to overwhelm us we need a view of the past to lift us up to a Mount Nebo from which we may glimpse the Promised Land and so renew the hope which enables us to push forward on our journey of discovery or to give us a sense of direction in what seems to be defeat. Thus, standing on the vantage ground of the present, we are able to use engineering history to survey the past and to project the crystallized thought of that past into the future.

We live in an age of extraordinary scientific and technical advance but we do not always recognize real progress when we see it —we lack the proper perspective. This is something which engineering history should give us, a bird's-eye view of the various aspects and personages of our profession. Other professions have it, why should we not? If we read the biography of only one person we are inclined to believe that that individual was solely responsible for the complete development of his field. But read further, the biography of his rival, his co-worker, and we are persuaded that other workers have made additions to knowledge in that field. There is nothing so inspiring, so informing, so stimulating to one who would advance his profession as to see how here a little and there a little the contributions of many people have been the grains of sand out of which have been built the mountains of knowledge which we possess. On the other hand there is a danger that we may regard some of the great figures as supermen, as those to whom there is no earthy substance clinging and who are therefore people unlike ourselves. Let us not forget that these geniuses had ambitions and disappointments, they too desired money, fame and appreciation even as we do, and that they too had loves and possibly hates. Engineering history helps to give this complete, fully rounded view, an outlook which we must have if we are to be really masters of our profession.

If each of you were asked to write down the names of eight or ten men of modern times who might be held up as stimulating examples in research, whose lives might be studied with profit, whose names would appear on the lists? In such a group as this one it is likely that every list would include one or more of the names of

Edison, Bessemer, Westinghouse, Pasteur, Watt, Steinmetz, Faraday, Smeaton, Marconi. And of course I would agree that your choices were excellent. Yet none of these names appear in my list today. The people I shall mention briefly are not selected as the most conspicuous examples of research men or the most important contributors to technical progress; they are merely selections from a galaxy of eminent men, stimulating and inspiring. They are from various fields of endeavor, one from public health, two from power and two from materials. They represent five countries and cover a period of about a century.

The first to be named is one to whom I feel peculiarly drawn, though why I do not know. He is that rugged old die-hard, that student and investigator of public health, Max von Pettenkofer (1818–1901). Born in Austria, he began work with his uncle, rather unhappily, as a clerk in a pharmacy while at the same time he studied medicine. After some meritorious discoveries in physiological chemistry he entered upon a political appointment which enabled him to devote himself to public hygiene. At about this time (1854) there was a severe epidemic of cholera and typhoid in Munich and he began studies of the water supply of that city. Through these studies he came to the conclusion that there was a specific agent in the soil which caused the disease and that poor drainage was responsible. For forty years he labored to improve the drainage and water supply of Munich and he had the gratification of seeing the death rate from typhoid fever drop from 149 per 100,000 to 3 per 100,000 in a period of 26 years. Though his theory was partially wrong his results were most successful. The painstaking work and the profound conviction of the man as well as the boundless energy he used furnishes a stimulating example for any research worker. He was human, perversely so, and most tenacious in his views, as shown by the fact that he never believed in the germ theory of disease, a strange state of affairs for one who accomplished as much as he did in the way he did. It is reported of him that he took from Koch's hand a tube containing a culture of cholera germs and drank the contents to prove there was nothing to the germ theory of disease. And he lived to maintain his point. Whether or not the story is true it exemplifies his courage and shows the assurance he felt in his own views. While I would not advocate this type of stubbornness as a necessary concomitant of research, it is true that the person who discovers new facts or projects old ideas into new areas must have a degree of confidence in himself and of faith in the correctness of the ideas which he espouses. Faith based on a background of knowledge is a valuable ally in research.

Let us now look at the field of power. The discoveries and in-

ventions of Watt and others at the close of the eighteenth century stimulated investigation in steam engineering which then advanced by leaps and bounds. Soon it had changed from an art and a craft to a science. Yet with all the improvements made in the century following Watt's first engines, the steam engine had not been changed in any essential way. The first modification of a really basic character came with the steam turbine, and Sir Charles A. Parsons (1854–1931) was a pole star in this transition of the prime mover. Born in Ireland, he was educated at Cambridge where the tradition of Newton still lingered to inspire and energize. Here also Robert Willis had bequeathed to his successors a vision in mechanical engineering. These influences, coupled with natural ability and early training, played upon the life of young Parsons. He began his work in 1877, only 17 years after Rankine had stated the correct equations of thermodynamics which showed that there was a large waste of energy in the utilization of steam. Parsons selected the turbine as the medium of reducing this waste. Though the turbine idea was centuries old the mechanical difficulties were great and these Parsons gradually overcame. He built his first machine, 10 H.P., operating at 18,000 r.p.m., in 1884 and followed it with a 600 H.P. turbo-generator station in 1888. But from a 600 H.P. stationary installation to one of 144,000 H.P. in the bowels of a plunging battleship is a long step. While this phenomenal growth was not all due to Parsons, he had his share in it, particularly in the adaptation of the turbine to ships. One of the prime difficulties was that of the failure of the metal due to the high velocity of the rotating blades. He decided to distribute the drop in steam pressure between the inlet and the outlet over a number of wheels and thus reduce the peripheral speed, a most effective scheme for reducing the stresses in the blades. His studies and achievements will long stand as pillars of Hercules to the voyager on the sea of steam engineering research and discovery. Particularly suggestive to us is the versatility he showed in adopting a substitute type of turbine when conditions seemed to preclude the use of the one he originally developed.

Let us now go back to a young Dane, Hans Oersted (1777–1851). Born in the home of an apothecary and possessed of few opportunities for education he studied by himself until he was able to attend the University of Copenhagen from which he was graduated. His interest was in science and naturally he was one of the devotees of the new and rapidly growing cult of experimenters in electricity. Though much was then known of both electricity and magnetism there was as yet no known relationship between the two phenomena. In 1820 young Oersted discovered and demonstrated such a relationship and thus laid a solid foundation for subsequent

studies of electrical action. The story is told that during a lecture he had a sudden "hunch" and placed a wire carrying an electrical current beside a suspended magnetic needle with the result that the needle was deflected. Be that as it may, he made the discovery and conducted many other experiments which revealed not only law-abiding phenomena but the laws which governed them. His researches helped to form the groundwork on which the present magnificent edifice of electrical engineering is reared.

The next person on my list is one of our own countrymen, William Kelly, the ironmaker from Kentucky (1811–1888). It is reported that he became concerned over the increased distance of charcoal from his ironworks and that this impelled him to look for cheaper fuel. Whether this is true or not he found that by blowing cold air through molten cast iron he was able to produce what was called wrought iron. He did this first in about 1847 and intended to use the process for the commercial production of iron. However, the opposition of his customers who were critical of the new iron and of his father-in-law who furnished the capital held him back. Later he obtained a patent on the process and in 1857 he built a converter at Johnstown, Pa. With further improvements his method was used for making large quantities of steel. Kelly himself derived relatively little financial reward from his discovery because his method came into direct conflict with patents on machinery held by Bessemer. In the final negotiations, with which Kelly had little or nothing to do, the Bessemer interests headed by Alexander Holley of Troy, N. Y., won out. Kelly was a modest man who lacked aggressiveness and while he regretted the loss which he sustained, in money and prestige, he had courage to hope and a will to work. Perhaps he should not be cited as a successful and inspiring research worker. Nevertheless he was and is one of the figures depicted on the canvas of research and progress. Any investigator will find in the account of his life a valuable lesson in persistence.

The final figure in my small procession is that of a Frenchman, Floris Osmond (1849–1912), one of the foremost workers in the metallography of iron and steel and one whose name is commemorated by the term osmondite. After some years of practical work in steel plants he devoted himself to private research. He discovered that iron forms chemical compounds and that these compounds form solid solutions with each other. He further discovered the thermal critical points of iron and with these laws and data he built up a remarkably brilliant conception of the action of iron and carbon compounds in cooling, the allotropic theory of iron. Thus he forged a key which unlooked the tangled secrets of the thermal transformations of steel. Osmond was thorough, cautious and

logical in his reasoning, generous, shy and reticent in his personality. He became deaf and because of this suffered keenly and finally became a recluse. When he was ill and knew that death was approaching, one of his last messages was that no biographical sketch of himself should be published. It was only after careful consideration that some of his admirers wrote briefly of him. This is the man to whom so much is owed for our present knowledge of the metallography of iron and steel. To me Floris Osmond is an inspiring personality both for what he did and what he was.

It is on the records of men such as those I have just described that the structure of engineering stands. Patient study, accurate experimentation, logical synthesis and critical interpretation have been the goal of many such investigators in the days that are gone. The record of their work is a part of our professional heritage and a part which we must cherish and utilize if we are to pass on still aflame the torch which has been handed to us. The past has a part to play in the advances of the future and discriminating reading with thoughtful study of the history of engineering will broaden our horizon, deepen our understanding and enable us to add our mite to the advancement of engineering knowledge. I commend such reading to you.

WHEN RESEARCH LEADS TO PATENTS

THE PROBLEMS INVOLVED IN THE SETTING UP OF A POLICY RELATING TO PATENTS AND PUBLICATIONS BY EDUCATIONAL AND RESEARCH INSTITUTIONS[1]

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General Considerations

In considering the problems involved in setting up a policy relating to patents and publications by educational and research institutions it will be found convenient first to make a twofold division of the situations which we are to study, namely, Case 1, where the research associate is employed by a college, university, or research institution to work on a part or full time basis and, Case 2, where the research associate is employed full time on the problem by the university or the research institution which in turn is serving as a research agency for an individual, a firm, or a group of firms which may or may not be associated together as a committee or in some other form of organization.

The problems incident to the first of these two cases are simply those of a college, university, or a research institution in its dealing with one of its employees. While these problems are at times difficult of adjustment they are not so complicated as those which arise in the second case when the interests of a third individual or group, particularly the latter, are added.

Before proceeding further in a study of the problems presented by these two general groups of situations, it should be stated that in the opinion of those who have had the most experience in and have given the greatest amount of thought to the handling of situations involving patents, they are at the best difficult and very complicated. Self-interest, human initiative, personal rights, organiza-

[1] The basis for this paper is a file of correspondence and pamphlets covering a period from 1920 to date which was assembled for the use of the A. S. M. E. Research Committee at the time it was setting up its policy relating to patents. This file includes data and expressions of opinion gathered together when The Engineering Foundation, the National Research Council, and the American Engineering Council were making similar studies of this important subject.

Presented at the Conference on Engineering Research, S. P. E. E., College Station, Texas, June 27–30, 1938, in Mr. LePage's absence by Mr. C. E. Davies, Secretary, A. S. M. E.

tional policies, contract law, patent law, business procedure, competition, etc., are a few of the elements involved. As a consequence, there is little or no possibility in our present economy to frame a policy or policies which would have any chance of being generally adopted in either one or both of the two cases suggested above.

In general it will be found most expedient to determine a patent policy for each particular contract so that it may reflect the exact circumstances which prevail and may be based on sound principles of human relations and good organization. In the first case where the variables are relatively few, there will be more opportunity for uniformity between the practices of one college or institution and another. The variables in the second case are, however, too numerous to permit the possibility of uniformity.

Case 1. When the Research Fellow is Associated with only One Organization

From the record it would appear that at present the patent policies in force in the several universities and research institutions, which employ research workers or fellows, vary all the way from (1) granting no interest in patents which result from the work of the fellow to (2) the granting to him or her complete ownership and rights. The problems implied in this situation are the problems of employee-employer relationship conditioned by the traditions of academic life and research procedures. They are, however, much the same as those met with in other walks of life. One dean, head of department, or professor takes the position that the research fellow is adequately recompensed by the salary that he is paid and by the other advantages of campus life. While on the other hand another supervising officer sees in the possibility of a discovery or an invention an opportunity to stimulate his research fellows to maximum effort, study, and reflection. He consequently offers them partial or complete participation in the discoveries or inventions which are direct outgrowths of their work. This means an outright payment or a participation through rights in the returns from a patent. In this latter arrangement the university or institution also may receive a share in the benefits, if any materialize.

Under the patent statutes of the United States an invention is patentable only to the original and sole inventor or inventors, hence the research worker concerned is an indispensable party in the process of securing protection on the invention developed. However, by conditions inserted in his contract of employment, he may be required to assign to the employing institution all, or any portion of, his rights in and to the inventions he may develop, both as to the United States and foreign countries.

Most patentable ideas or devices must pass through a long period

of development before they are of value commercially. Frequently, also they must pass through the fires of one or more litigations. The owners of the patent or those to whom it has been assigned in one form or another must give the necessary time to handling this business and must cover the high cost if they intend to enforce the patent rights. Some who have had this experience maintain that, in many cases, a patent may become a liability rather than an asset.

A number of universities and research institutions that have been conspicuous in their support of research have set up special boards or foundations to handle the commercial development and exploitation of patents. The proceeds from royalties, sales or other sources of income are utilized in major part to support research in the institution. Some of these foundations frequently grant bonuses to the individual or individuals responsible for the discovery or invention.

Some institutions receiving patents by assignment from research workers, where such research is paid for by public or other funds, dedicate the inventions to the public on the general principle that educational institutions should not profit from commercial connections which may prove embarrassing. Such embarrassment might arise under conditions where such educational institutions profit from such connections and thus may involve a tax situation which would be prejudicial to otherwise tax-free income and property.

Also institutions have dedicated inventions to the public with provisions for licensing in order to control quality and keep price down so as to make available to rank and file at reasonable cost such discoveries as have medicinal or therapeutic properties, or which are of general public benefit.

Still others permit the individual making the discovery to patent it and then to exploit it commercially. In this case, however, shop rights are frequently reserved by the institution, either by virtue of law or as the result of a definite provision in the contract to that effect.

One who has had extensive practical experience in this field believes "that a good patent is as proper a source of income for an individual as the authorship of a good book.* If the holder of a patent is freed to some extent from financial stringency and care, he will be the better able to devote himself to further scientific discoveries and useful inventions.

"But there are even better reasons for patenting new ideas whenever possible, and for the discoverer or inventor holding the patent himself. He can push it with more knowledge and energy

* Yandell Henderson, Ph.D., Professor of Applied Physiology, Yale University, in the March 31, 1933 issue of *Science*.

and can control it for the general welfare more effectively than can the financial officers of a university. Inventions, like all new ideas, have generally to be forced on conservative mankind. It would be easy to point to many inventions and other applications of discoveries now saving large numbers of lives that would not yet be in use without advertising and the efforts of salesmen. Without commercialization a large part of all scientific ideas that are now in constant and active use in our daily lives would be locked in books on the dusty shelves of university libraries."

The contract which the research worker has with the institution will state, obviously, the purpose of his work. Should he be employed for the specific purpose of developing an idea or to find a solution to a problem, or should the contract specificially call for the assignment or transfer of all patentable results of his work, then the title to the patent or invention resides with the institution or the foundation which it may have set up. Past experience has shown that control by such an organization is often very essential and in the public interest but such ownership and control do not necessarily preclude adequate remuneration to the research worker who made the discovery or invention.

In contracts or agreements with research workers disclosures of any kind by an inventor or research worker must be controlled, otherwise publications, discussions, and demonstrations may occur which are of such a character as to nullify any possibility of protecting properly an invention either in the United States or foreign countries; or may be so premature as to give unscrupulous outside agencies sufficient information with which to hamper considerably the original inventor in obtaining a patent.

Generally speaking educational institutions maintain a liberal policy with respect to publication. Papers and reports based on the results of research in pure science are not usually subjected to censorship by the authorities. In most cases formal permission for publication is granted simply on application. Where the research fellow is also a student working under a professor in charge, the publication is usually a joint paper. In practically all cases of research leading to a degree the thesis or dissertation is considered to be the property of the institution and cannot be used by a student for publication without the expressed permission of the authorities in charge.

Case 2. When a Number of Individuals, Firms, or Organizations Have Direct Interest in the Work of the Research Fellow

We now come to the consideration of the second case referred to above, namely, where the research fellow is employed full time

on the problem by the university or the research institution which in turn is serving as a research agency for an individual, a firm, or a group of firms which may or may not be associated together as a committee or in some other form of organization. The introduction of the third and sometimes the fourth party to the contract increases greatly the complication of the problem. To (1) the rights of the individual and (2) the patent policies of the university or research institution we now have to add (3) the patent policy of the industrial firm or the group of firms together with that of a sponsoring society or association where there is one, (4) the complications relative to shop rights, exclusive and non-exclusive licenses to the subscribers and nonsubscribers, and the resulting royalties; and finally (5) the rights of the general public.

Some firms approach a research institution and its scientific talent for assistance after they have spent much time and money in a given development. They need some help in a specialized field unfamiliar to the members of their staffs. If the scientist who is assigned to their investigation is successful in solving their problem, they will be grateful and will consider the just charges for the service well earned. However, should he be allowed to take out a patent in his own right with the knowledge thus obtained a great injustice is likely to be done to the firm whose years of study and development work entitled it to all of the benefits of the art that has been thus created. To avoid situations of this character it is necessary for industrial research institutions to include in contracts with research fellows provisions that results obtained are to be the property of the sponsor or donor, and that all inventive subject matter and patents obtained thereon shall be assigned to the sponsor or donor as the case may be.

Some take the other extreme view that no patents should be taken out on the results of coöperative research. To them the application for a patent on the results of coöperative research is no more justified than keeping secret the information thus obtained for the benefit of a restricted group. They hold that full and general publication is the best course.

However, the efficacy of this latter method of procedure is seriously questioned by others. They point out that under the patent laws of this country such a practice would prove to be ineffective in protecting either the discoverer, the sponsoring group, or the public. There is a provision in the law whereby a patent may be applied for within a period of two years after the announcement of a discovery or even after it has been put into commercial use. In consequence of this provision it is possible that after publication of the details of a discovery some worker in the same field or some interested party might file a patent application which

would result in a patent if the Patent Office did not know of the publication or the use or, even if it did, provided the applicant furnished an affidavit alleging that he had made the invention before the date of publication.

The contracts which cover the relationship between a research agency and a sponsoring body, whether it be an individual firm, a group of firms, a trade association, or a technical society usually contain some kind of a reference to the handling of a patent situation should it arise in the progress of the research. There is a provision in the Patent Laws that requires the inventor to make oath that he does not know and does not believe that the invention was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to his application for patent in the United States, or in public use or on sale in the United States for more than two years prior to his application for patent. Thus, it will be obvious that it is inadvisable to make indiscriminate and wide-spread disclosures as these sometimes result in unscrupulous parties engaged in the same field of effort filing conflicting applications with consequent expensive interference proceedings to determine who, in fact, is the first inventor.

The clauses in the contract should cover, first, the rights reserved by the sponsor organization. These may range from complete and exclusive ownership by the individual, or the group of firms, or an associated society to an assignment to the general public. If the former or an intermediate position is taken, then the method of distribution of the benefits, if any, should be specifically covered. This involves the reward to the research fellow, assignment of shop rights, granting of licenses to the members of the sponsoring group either free or on a royalty basis, and a provision covering the method of handling the participation of nonsubscribers.

Because of the difficulty of drafting in advance clauses of this kind which will be satisfactory to all concerned, some sponsor organizations have found it best to omit them from the contract covering the research project and to deal with a patent situation as a special problem if and when it arises. If this course is taken, a provisional paragraph could be inserted in the contract.

Present Tendencies

One well known industrial research laboratory provides in its fellowship agreement for the publication of the results of all investigations after three years have elapsed provided such publication will not unduly injure the sponsor's interests.

A method of conserving the interests of the research fellow,

the research agency, the industrial firms and associated organizations, and the general public which seems to be growing in favor provides for the final assignment of the patent to a non-profit foundation organized for this particular purpose. The contracts and agreements made with such a corporation would specify exactly how and in what proportion the benefits resulting from the commercial development of a patent would be distributed. Some of these corporations undertake also to develop and exploit the original discovery or invention. In this case the public may profit by the application of a certain proportion of the proceeds of inventions to the assistance of other inventors in the development of their discoveries or inventions.

Summary. Case 1

1. All contracts between research fellows and a university or research institution should contain a reference to the possibility of a patentable invention resulting from the study to be undertaken.

2. Assignment of a patent resulting from a study made for a particular purpose directly to the institution, the employer, is the normal procedure. The control and administration of such a patent, however, either directly or through a foundation should be equitable to all concerned—the research fellow, the institution, and the general public.

3. Should a research worker or a professor engaged in general research either on a full or part time basis happen on a discovery of an invention then it will be time enough to enter into a specific agreement as to patent rights, royalties, etc., providing that a clause, as previously mentioned, has been inserted in the contract. A small committee made up of disinterested members of the faculty and research personnel has been found to function well at such a time. Ownership to such intellectual property has been repeatedly held by the courts to reside in the person doing or directing the work which resulted in a discovery or an invention.

Case 2

4. More formality is involved in a patent situation when industrial groups are associated with the research agency financially and otherwise. Here also the principal purpose of the research may be to develop new knowledge with the possibilities of an invention remote. So, while reference to patents should be made in the contract, it need not be explicit. A patent agreement between all interested parties may be drawn up later in the light of the circumstances as they then exist.

5. The coöperative committees of technical societies, the co-

operative research councils of industrial groups, and other similar organizations usually include specific clauses concerning patents in their contracts with research agencies.

6. Many hold that the results of research conducted at government laboratories and at those of state and endowed universities, whether or not they lead to patentable discoveries or inventions, should in time reach the general public.

Discussion

L. M. K. Boelter, Professor of Mechanical Engineering, University of California: At the University of California, faculty members are free to act with respect to patentable material in any manner which they see fit. The President of the University, upon request of the faculty member concerned, will appoint a special committee to report on the merits of an invention or discovery and on the advisability and methods of securing patents.

Several inventions and discoveries have been sent to the Research Corporation of New York for financing and disposition of patents, under the procedure noted above. If the patent is accepted, royalties, if any, are subject to agreement between the Research Corporation and the inventor.

It is understood that from time to time the Research Corporation will, at its discretion, allot contributions for research to such institutions from which profitable inventions have emanated. The Research Corporation, however, owns such patents as have been discussed heretofore.

Often faculty members make their own arrangements with industrial units, or in the case of discoveries and inventions by members of the staff of the College of Agriculture, the data have been transmitted to the U. S. Department of Agriculture with the recommendation that they be considered for public service patents.

H. A. Everett, Head, Mechanical Engineering Department, The Pennsylvania State College: Mr. LePage's paper presents an excellent summary of the problems involved in any policy relating to patents resulting from research programs. From the educational institution point of view, I quite agree with his comments as summarized in Case 1. It is essential that the stimulus of financial reward and credit be retained in any collegiate research work. Workers in this field are almost invariably underpaid and if the results of their work can be made to produce financial income, this income should be so controlled that some portion of it should revert to the originator of the idea.

With us the control and administration of patents rests with a non-profit foundation drawn from the college staff, and this group assists in the obtaining of the original patents. This latter is a

step which is particularly helpful, as frequently the financial burden involved in obtaining a good patent is more than an individual cares to undertake. In such a manner the discoverer is first advised concerning the value of the patent, then relieved from the financial burden of obtaining the patent, and finally receives some financial reward if the patent becomes commercially successful. We feel that this arrangement is a sound one and results to the advantage of both the institution and the individual.

Arthur M. Greene, Jr., Dean, School of Engineering, Princeton University: Princeton has recently formulated a patent policy controlling the issuance of patents to members of the University. We have provided for a patent committee and have also entered into a contract with the Research Corporation by which they would undertake the prosecution of patents for worthy inventions of members of the University, which includes faculty as well as members of the graduate and undergraduate groups. The agreement also permits individual members to take out patents on their own responsibility and provides in such cases that the patent shall be submitted to the Patent Committee for the determination of any equity which may belong to the University on account of facilities offered by the University in the development of the invention.

I am very glad that Mr. LePage has mentioned the matter of the public in his paper as we feel very strongly that patents should be taken out on meritorious inventions so as to protect the inventor and the public from improper use of the invention as well as the possible granting of the patent to a person who had not made the discovery.

C. F. Hirshfeld, Chief of Research, The Detroit Edison Co.: I have read the paper with interest because it deals with a subject which I have had to consider from time to time in various capacities during the past twenty years or more. Mr. LePage has given a very fair statement of the problems and methods. I do not believe I can add much of value to what he has written except to emphasize the fact that discussion and treatment of these problems should both be realistic rather than idealistic. Many institutions in their idealism have actually retarded their own development and human progress by failing even to permit the presentation to them of realistic points of view.

Joseph O. Lange, Engineer of Patents, Crane Co., Chicago, Ill.: In reading Mr. LePage's paper, I am reminded of a case entitled U. S. *vs.* Dubilier Condenser Corp. (289 U. S. 177) which came before the U. S. Supreme Court and which was decided on April 10, 1933. Two scientists employed by the United States in the Radio Section of the Electric Division of the Bureau of Standards, while assigned to research concerning the use of radio in aeroplanes,

made discoveries concerning the use of alternating current in broadcast receiving sets, a subject not within their assignment and not being investigated by the Section. With the consent of their superior they perfected their inventions in the Bureau's laboratory and obtained patents. It was held, under such circumstances, that there was no employment to invent and no basis for implying a contract to assign to the U. S. Government or to establish a trust in its favor, except as to shop rights. The latter expression substantially amounts to a non-exclusive license.

The U. S. Supreme Court held that the proposition that anyone who is employed by the United States for scientific research should be forbidden to obtain a patent for what he invents is at variance with the policy heretofore evidenced by Congress, and the Court further held that if public policy demanded such a prohibition, then Congress and not the Courts should declare it. The analogy drawn is that the Government in this particular instance was placed in the position of a state endowed institution. The Government in the presentation of its attempt to recover the exclusive use to the patents sought such result by forbidding one who is employed by the United States for scientific research to obtain a patent for what he invents, though neither the Constitution nor any statute so declares.

It is my opinion that where a third party is involved in a research project, then there is an implied contract that such third party, to the exclusion of anyone else, should be permitted to control the patents resulting from such research work. Further, however, the question of whether or not the research worker was employed to invent enters into the determination of the respective rights of the individual parties. Obviously if the research worker is employed for that purpose, then the invention should be a legal obligation but assigned to the party paying for the research work, and neither the school nor the research worker has even as much as a shop right in the process.

Where the invention occurs by reason of the use of the employers' time and materials, then it seems logical that the school as well as the party paying for the research work should have shop rights in the invention, considering of course that the invention is not within the scope of the project undertaken but merely happens to be a discovery occurring during the course of the investigation.

Therefore, in Case 1 (where the research associate is employed by a college, university or research institution to work on a part or full time basis) it would seem logical that any invention within the terms of the project should inure to the benefit exclusively of the school or employer.

In Case 2 (where the associate is employed full time on the

problem by the university or research institution which in turn is serving as a research agency for an individual, a firm, or a group of firms which may or may not be associated together as a committee or as some other form of association) by the same reasoning the principal employing the research institution as one of its agents is entitled to the same benefits which would ordinarily inure to the school or institution. This conclusion is based upon a well established axiom in the law of agency that the principal is entitled to all of the benefits inurring to the agent within the scope of his duties whether or not such benefits were specifically known to the principal at the creation of the agency.

It would seem to me, therefore, that the better practice would be to provide *definitely* in advance for the proper delegation and use of patents rather than to rely upon any arrangement subsequently attempting to set forth the respective rights of the parties. To do otherwise might result in injury to one party or the other because of the urgency of the situation later developing, and perhaps based upon circumstances not previously existing nor anticipated.

I have treated this subject merely from the standpoint of one phase of its legal consideration, realizing that the case quoted has created a very definite influence in the employee-employer relation construed by the highest court in the land.

M. F. Sayre, Professor of Applied Mechanics, Union College: I am rather inclined to suggest that this topic should be subdivided into Case 1—Patents Rights, and Case 2—Rights of Publication, rather than into Mr. LePage's Case 1 and Case 2.

As a generalization, every one will probably agree that the potential benefits from patents arising in such cases as are here referred to should be divided between the respective parties in proportion to the share which they have contributed toward the research, taking into due account the risks incurred by the sponsor of receiving zero or negligible returns from his investments in the research. Obviously no generalization is possible as to the share contributed by the research worker himself. The problem before him may have been rather clearly stated before he entered the research; and the sane selection and clear statement of the problem is usually a very important factor leading toward success. He has drawn upon the general public store of knowledge. In coöperative work, he has usually had considerable special information and advice from the sponsors. He has drawn upon the supply of apparatus owned by the institution, and in case of a research fellow, has usually had guidance from senior professors at the institution, and may have had records of negative or positive results obtained by previous research fellows.

If, in addition to receiving this help, the research fellow is paid for his time, it is obvious that his claim to ownership of resulting patents, as a matter of right, is likely to be a rather small one. Usually, as suggested by Mr. LePage, the natural procedure will be the assignment of rights to the patent to the sponsoring body or to some agent designated by it. From the point of view even of the inventor himself, this is likely to be advisable, since the necessary steps involved in obtaining a valid patent, so written as to cover all rightful claims, and in later disposing of or developing the invention, will usually be time-consuming and expensive and call for a type of skill which the research worker himself will not have. One difficulty, however, in assigning patent rights to any university except a very few is that the university is not likely itself to have at its disposal this type of skill, or to be willing to bear the necessary development costs.

The amount of payment to be made to the research worker is a more difficult matter to determine. Often the fairest solution would be an initial arrangement for a salary commensurate with the research fellow's real ability, the risk of positive or negative results being borne by the sponsoring institution, which after all has usually selected the problem. Even here, a bonus for exceptionally good results or for discoveries of commercial value arising outside the original field of the research would seem to be advisable from the standpoint of good policy as well as that of fairness.

The problem of publicity of results is quite a different one from that of patent rights. Save under exceptional circumstances it would seem to be of doubtful advisability for any educational institution or endowed research institution to accept research problems except with an understanding that the results obtained are to be published with not too great delay. Problems the answer to which is to be kept secret belong more properly in private laboratories, or if for reasons of convenience (special equipment or special training of workers) they are undertaken by educational institutions, it should be only with the understanding that full costs, including overhead, should be borne privately, and that workers are to be fully paid for their time and skill.

Only a comparatively small percentage of patents, even after costs of issuance have been paid, have any large commercial value, and ordinarily, right of publication, with the resulting gain in reputation, is likely to average of more real value to young research fellows than these purely hypothetical patent rights. There are of course occasional brilliant exceptions. Lacking definite agreement to the contrary, and subject to reasonable delay if requested by the sponsors, research fellows should be entitled to this right of publication, the authorship to be listed either individually or jointly

with others, depending upon the way in which the work itself was handled.

The comments made up to this point refer to what might be termed subsidized research carried on by men part or all of whose time is definitely understood to be devoted to research. Discoveries of commercial value made by members of the faculty, paid by the school primarily for their teaching work, and with negligible or no time allotment for research, constitute yet another problem, and may well be a matter for preliminary understanding. Lacking such preliminary understanding, there would seem to be no valid reason why patent royalties should be any less a matter of private ownership than should, for example, be book royalties on books written by members of the English or Economics departments. To my knowledge, no claim to institutional ownership to these book royalties has ever been made, and yet college library facilities may be quite as necessary and expensive a factor in the one case as were laboratory facilities in the other case.

J. H. Walker, Engineer Assistant to the General Manager, The Detroit Edison Co.: Mr. LePage has most ably presented the problems involved in patent policies. He apparently recognizes the fact that stating the problem is about as far as one can go in such a discussion. The actual policy chosen will in each case depend upon the viewpoint and philosophy of those individuals and institutions who have the matter in hand.

A few points might be mentioned in amplification of, but not in disagreement with, the paper. One is the injustice which can sometimes occur if royalties go entirely to the patentee in disregard of other individuals who have contributed as much or more than he to the development of the invention. The patent system is a governmental method of securing for the individual citizen certain rights to the product of his brain. But a patent should not necessarily be the sole criterion as to the distribution of profits among individuals of an organization. In some cases gross injustice and great damage to morale may result from the disregard of this obvious fact.

Another point not to be lightly disregarded is the possibility of violent objection on the part of industry to the collection of royalties by a tax-supported institution. Should an industry pay royalties under, or be hampered by, a patent covering inventions evolved in an institution to which that industry is contributing tax money? The answer that the research work which led to the patent is partly or wholly paid for by a sponsor is not an entirely adequate answer. The institution and indirectly the taxpayers have usually contributed in one way or another to the project.

Mr. LePage points out the question in the minds of some as to

whether any patents are worth the difficulties which they involve. The conspicuous cases of enormous rewards earned by basic inventions should illustrate the importance of patent protection. Many mistakes are made, however, in taking out patents which are not basic and which can have no great commercial value. Too little thought is often given to the probable value of a patent before the money and effort are spent on it. A realistic evaluation would often save a great deal of trouble. Important inventions should be patented and the workers in institutions should be permitted to share the profits in some equitable way. If more and better brains are wanted in our laboratories, no more effective attraction can be offered than the hope of financial reward.

A. E. White, Director, Department of Engineering Research, University of Michigan: After years of experience with matters relating to patent policy for educational and research institutions, it is doubtless safe to state that no one policy will be found acceptable to all interests. Various institutions have their own policy and it has been found that even in the same institution different units may not operate under the same policy.

Mr. LePage has divided his subject matter into two "Cases." One deals with the plan whereby workers are supported by university grants or by foundations which have no particular interest in exclusive benefits from any patents which might result; and the other deals with the plan whereby research workers are supported by agencies which, in many instances, look forward to possible financial returns from patents.

With regard to the first case, it is felt that it is very proper and fitting that "all contracts between research fellows and the university or research institution should contain a reference to the possibility of a patent or invention relating to the study to be undertaken." Although it is agreed that this reference need not be explicit, it would be helpful if a definite policy could be established on this point.

It is questioned if an educational institution should accept the direct assignment of a patent. Such assignments are liabilities as well as assets. The writer knows of no educational institution which is so set up as to protect patent rights, nor no educational institution which could effectively bring the patent to those who could carry work forward under its provisions. The most practicable method of handling patents appears to be through foundations set up under the provisions of an educational institution to administer them. These foundations are in a position to administer patents properly and they free the educational institution from the possibility of litigation.

I beg to differ with the conclusion that "Should a research

worker or professor, engaged in a research, either on a full- or part-time basis, happen on a discovery or invention, then it will be time enough to enter into a specific agreement as to patent rights, royalties, etc." This procedure may be satisfactory in the case of patents which are of no moment. It is questionable if patents of this type should be applied for, anyway. In the case of patents, however, which contain valuable provisions, precious time is lost in setting up machinery for their administration.

With respect to the second case, I cannot agree with the thought that "while reference to patents should be made in the contract, it need not be explicit." It has been our experience that one of the first questions raised by most industrial groups is "what are the arrangements for handling patents?" Many industrial organizations will not place research with agencies which will not tell them in advance what procedure may be expected with respect to the administration of patent rights.

The results of research conducted at Government laboratories and at state and endowed universities should be so administered that patentable discoveries or inventions will, in time, reach the general public. However, I do not believe that the best way to do this in all cases is by the direct assignment to the general public of the patents resulting from discoveries or inventions. In fact, such a course oftentimes results in the general public failing to receive benefit. It must be recognized that patents are oftentimes but a prelude to a general development. Industrial organizations would hesitate to make large expenditures in developing a patentable idea into a product for public consumption unless they were assured of some protection over a reasonable period of years. The Government, by the very establishment of the Patent Office, recognizes this principle.

I wish to congratulate Mr. LePage upon the clearness with which he has presented the general subject. It is, at best, a difficult paper to prepare and one which probably involves many differing view points.

C. E. Williams, Director, Battelle Memorial Institute: Mr. LePage's appraisal of the patent problems confronting a research organization states them very well. Patent protection is a factor in almost all research of a practical nature, and must be reckoned with, though often the only positive value of a patent lies merely in its defense against being held up by some later inventor.

At Battelle Memorial Institute the patent problem is always handled by definite contract, not left for determination after a patentable discovery has been made. The employment contracts with employees bind them to prosecute applications and assign them to the Institute. There are no exceptions to this. Should an in-

vention be in a field remote from those dealt with at the Institute, so that the Institute does not wish to develop it or bring it to the attention of a possible sponsor, the invention is formally released to the employee.

In all contracts with sponsors, for whom commercial research is carried on at their expense, the ownership of patents is definitely defined, whether the sponsor be an individual, a firm, a temporary group of firms, a trade association or other organization. Unless the sponsor otherwise stipulates, all patentable inventions relating directly to his problem belong wholly to the sponsor. In rare cases, sponsors stipulate that patents will not be taken out, but all results made available for general use. Groups interested in the wider application of a particular raw material sometimes take this attitude. Individual manufacturers almost invariably prefer to be able to take out patents under their sole ownership. This does not mean that patents are taken out on every little patentable kink, but merely that when something basic or important crops up, it may be patented if the sponsor wishes.

We have some sponsorships established for the development of fundamental information rather than for definite and immediate commercial purposes. Such projects are supported by a firm or an industry which recognizes its need for more information on its products or processes, and looks for such information from the long-range viewpoint. In these, patentable discoveries are not directly contemplated and the results are expected to be published. In the event that something worth patenting ensues, a separate, commercial type sponsorship may be set up for the following of the lead that appeared to have immediate commercial possibilities, with the sponsor carrying the cost and having ownership.

Whatever the situation may be in which the problem of patent ownership can arise, it is better to have that ownership as definitely prearranged for by contract as possible.

The matter of publication is equally important with that of patents. Battelle contracts with commercial sponsors stipulate that, while data are the property of the sponsor, no use may be made of the Battelle name in advertising or sales promotion without specific permission. Publication of articles and presentation of papers before technical societies, usually under joint authorship of a sponsor's representative and of a member of the Battelle staff, is the method usually chosen for publicizing the results of sponsored research. The contracts stipulate that publication must be approved by both the sponsor and the Institute, either one can veto publication. This avoids the possibility of premature publication by the sponsor of incomplete information, or of publication by the Institute of material which the sponsor wishes to keep confidential.

W. R. Woolrich, Dean, College of Engineering, The University of Texas: The paper of Mr. C. B. LePage is most timely. The practice of granting patents and the issuing of publications by Federal, State and endowed research agencies varies so greatly that the non-technical observer sees in it only confusion. Some of our most prominent research directors insist that employed research workers should be paid in full for their work and time, and should not be permitted to share in the fruits of any invention. They have had experiences of men losing sight of the main objectives of the investigation to which they were assigned and diverting their energies to some less important "quick money" invention.

A few additional comments might be added to the paper of Mr. LePage to emphasize the need for a well established policy in any research division. These are outlined briefly under four items which should be a part of any research program:

(1) The research worker should be given inspiration, direction and essential aid.

(2) Those who provide the funds should be given assurance that their financial support is not for the personal gain of the research worker or the staff.

(3) Any invention should be fully protected by patents to protect the inventor, the institution and/or the donor against unprincipled applications of the invention or discovery and excessive and uncontrolled production.

(4) The research should be sufficiently financed, organized and established to make possible the development of the invention beyond the laboratory state to actual pilot plant installation.

Referring to (1), it would seem desirable in any research program to extend to the research worker adequate assurance that his contribution shall be appraised by a sympathetic committee or board and that he shall be given certain compensation for the assignment of his patents to the employing institution or department.

Under (2), on the other hand, we cannot expect either the commonwealth or individual donors to accept the principle that they should contribute money for personal gain of an employed research investigator. Such award as is made to the inventor should be incidental to the transaction.

The statements given in (3) are in themselves partially self-explanatory. Most patents at their best are not producers of great revenue, especially for the first five years of their application. It is very essential, therefore, that the investor be offered reasonable patent protection to prevent indiscriminate competition until he has received ample reward for his investment.

Item (4) is often overlooked in our Federal and university laboratories. Too many of our laboratory discoveries and inven-

tions are left in the laboratory stage by the research worker. Discoveries left in this condition might be utilized by the larger industrial organizations, because they have sufficient research staff to place them on a commercial basis. Many of our government discoveries have been fruitful for the larger industries, but have contributed little to the smaller manufacturer. The small manufacturer must of necessity have a limited research staff. If he is to be aided, research should be carried on through the pilot plant stage and given sufficient support to provide semi-commercialization before it is turned over to the manufacturer.

In conclusion it would seem, therefor, desirable for every major institution doing research work that it should: (*a*) Have a well ordered patent and publication policy and (*b*) Make provision through a research foundation or corporation for the commercial introduction of these discoveries to accomplish the most good for the most people with due recognition being given to the research worker, the university or college and the donor.

Author's Closure.—It is gratifying to note the interest in the subject of this paper as evidenced by the discussions and constructive comments of the several discussers who are active in the field of research and its use in the solution of some of the problems of industry. While some differences of opinion were expressed, they are not as great as might have been expected judging from the differences in practice which now exist in educational and research institutions.*

The discussions which have been received so far seem to support the following procedure in both situations—(*a*) when the research fellow is working under a contract with one institution, educational or industrial, and (*b*) when a third or fourth party is added as a sponsor for the project:

(1) that the contract with the research fellow or associate should contain clauses outlining definitely his responsibilities and rights in the event that an invention results from his activity;
(2) that should a patentable invention result from the research or investigation due consideration should be given to the desirability of making application for patent rights to protect the interests of all concerned, the decision of this question being influenced by the nature of the invention;
(3) that, if a patent is secured, the interests of the research fellow, the educational or industrial institution, the sponsoring

* Before closing the discussion I desire to thank H. H. Snelling of Snelling & Hendricks and B. R. Newcomb of The Babcock & Wilcox Co., who gladly reviewed an earlier draft of the paper and gave valuable suggestions for its improvement at important places.

firm or organization, if any, and the general public should be carefully guarded in the assignments that are made;

(4) that those to whom the patent has been assigned have an obligation to provide for its development and subsequent commercial application; and

(5) that arrangements for the publication of the results of the research must necessarily be influenced by the sponsorship of the project and the decision concerning patents. Publication does not serve the same purpose as a patent. It does not even protect the public's interests where a patentable invention is described. Publication should, however, be made in some form at the appropriate time.

SECTIONS AND BRANCHES

UNIVERSITY OF DETROIT BRANCH ACTIVITIES

By CLAIR C. JOHNSTON

Professor of Civil Engineering, Chairman of the Branch

The following report was presented at the session of Sections and Branches held during the June 27–30 meeting of the Society at Texas A. and M. College. Being the only branch representative in attendance, the subject matter was presented with some uncertainty as to the interest it would elicit. George W. Case, Chairman of the Committee on Sections and Branches, and other delegates present, indicated by their comments that the report was of timely interest, especially to those educational institutions contemplating the establishment of similar branches.

The Executive Committee of the Society authorized the formation of a University of Detroit Branch in January, 1935. The objectives of our Branch are, "to explain and discuss projects and developments in the College of Engineering and in the University; to give members of the faculty an opportunity to address their fellow members on matters pertaining to the engineering profession, the College of Engineering or the University; and to promote in every way possible the well being of the College of Engineering, of the faculty, and of the students."

The officers of the Branch are elected in December for a period of one year, no officer being allowed to succeed himself in office the following year. The officers consist of a Chairman, Vice Chairman, and Secretary. Regular meetings of the Branch are held on the third Tuesday of each school month. These meetings constitute regular monthly assemblies of all faculty members, the business of the meeting being conducted by the officers of the University of Detroit Branch.

Since its inauguration three and one-half years ago, we have found that our activities have helped to keep the faculty S. P. E. E.-minded which has stimulated an increase in our national society membership. At the present time fifteen of our eighteen faculty members in the College of Engineering are members of the Society.

Our Branch has also affiliated itself with other Michigan universities and colleges to form a Michigan Section which meets annually for a one day period to promote good fellowship and an

exchange of ideas on engineering education. This group comprises Wayne University in Detroit, The University of Michigan, Michigan State College, the General Motors Institute of Technology, and Grand Rapids Junior College. The officers of the Michigan Section are distributed among these colleges and each college in turn becomes the host for the annual get-together. The greatest benefits derived from the Section Meetings have been:

1. A wide acquaintanceship with our neighboring colleagues, and

2. A stimulated interest in methods of engineering education.

One of the first important problems to be considered by our Branch was the preparation of a syllabus for each course taught in the College of Engineering. Dean C. J. Freund recognized the need of such an outline and appointed a committee early in 1936 to investigate existing syllabi in other institutions and present a form that would fit our own particular demands. The form finally adopted was considered comprehensive enough to meet our present needs and satisfy the requirements of accrediting agencies. It includes a statement of the objectives which a course is designed to attain, the text book used, a brief description of the course, the prerequisites, the subsequent courses, an outline of the material covered during each week of the Course, and the reference material pertinent to the course. This was an undertaking of considerable magnitude, but at the present time most of this work has been completed. The preparation of these syllabi has greatly assisted the faculty in an orderly arrangement of their course material; it has assisted them in maintaining a definite schedule; and it has more firmly fixed in their minds the minimum requirements of a course and its ultimate objectives.

Another problem which our faculty considered was the adoption of a proper form to be used in writing laboratory reports. Each professor had his own arrangement and content and no two were identical. This condition created confusion in the minds of the students and therefore needed correction. A Committee on Report Writing was appointed and made an exhaustive search among governmental and industrial reports. It drew up a modified form representative of the important items and their proper order in reports which the student would encounter in practice after graduation. This form was adopted, and while its exclusive use is not compulsory among the departments, most of them have signified their intentions of using it.

In keeping with our objectives of having faculty members present subject matter which is related to our field and which would broaden our point of view, our Branch devoted one meeting to a discussion of "Modern Aspects of Physics" and three other meet-

ings to a consideration of "Some Philosophical Implications of Modern Physics as They Concern Engineers."

The discussion of "Modern Aspects of Physics" was ably presented by Edward D. McCarthy of our Mathematics Department and dealt with an explanation of the Quantum Theory and the Theory of Relativity.

Father Remi J. Bellperch, Regent of the College of Commerce and Finance, gave an illuminating dissertation on "Some Philosophical Implications of Modern Physics." He firmly convinced us that a modern philosopher is well steeped in the broad scientific methods that are the tools of the engineering profession.

At the close of this school year we were concerned with the efficacy of our library facilities, and with the problem of stimulating a greater student use of the library in the College of Engineering. The Library Committee found that our problem was similar to that of most institutions of higher learning. Voluminous data and information are available on the devices that have been tried by other institutions, and in most cases the results attained were encouraging. The recommendations of this Committee finally adopted were based on conditions peculiar to our own institution and included:

1. The installation of some open book stacks containing a part of the technical literature now secluded in closed stacks. It is felt that, in addition to reference material now available in reserve shelves, other important publications would be more widely used if placed where the student could browse and read without first thumbing through a catalog index.

2. That in addition to the assembly period now given all freshmen during freshmen week, some time in the English course be allowed for a trip to the library where an explanation of the library service and facilities would be explained by the librarian. This procedure would supplement the present practice of assigning papers in English which require considerable library research.

3. Seminar courses were recommended, but to prevent overloading an already crowded curriculum, it was felt that each department could stress the proper procedure in ferreting out supplementary technical literature.

Our tentative plans for the coming year include discussions by the department heads on the technique each particular department is using, and an investigation of methods to be used in assisting students to develop their personality while in college. We feel that our Branch Meetings have stimulated team work among our faculty, and are certain that they will continue to be a medium through which diversified opinions can be crystallized for the benefit of the College of Engineering and of the University.

The Fall Meeting of the **New England Section** of the Society was held at the University of Maine, Orono, Maine, on Saturday, October 8. The total registration was 220 members and guests.

Registration was held from 9:00 A.M. to 10:00 A.M. in the Alumni Gymnasium.

From 10:00 A.M. until 12:00 M. five professional conferences were held. These were as follows:

A. Chemical Engineering—26 Lord Hall, Attendance 20.
Chairman: Professor Frank C. Howard, W. P. I.
Subject: Coördination of the Unit Operations Laboratory and the Lecture Courses.
Speaker: Professor C. P. Baker, Northeastern University.
Discussion: Professor L. C. Jenness, University of Maine.
Subject: Problems in Chemical Engineering Design and Operation.
Speaker: Professor C. C. Furnas, Yale University.

B. Civil Engineering—14 Wingate Hall, Attendance 30.
Chairman: Dean Frank W. Garran, Dartmouth College.
Subject: Undergraduate Preparation for a Career in Sanitary Engineering.
Speaker: Dean H. P. Burden, Tufts College.
Subject: Model Analysis in the Teaching of Structures.
Speaker: Professor J. B. Wilbur, M. I. T.

C. Electrical Engineering—Little Theatre, Attendance 29.
Chairman: Professor E. R. McKee, University of Vermont.
Subject: Electrical Engineering Courses of Non-Electrical Students.
Speakers: Professor L. W. Hitchcock, University of New Hampshire, Dr. C. A. Pierce, W. P. I.
Discussion: Professor C. L. Dawes, Harvard University, Professor W. B. Hall, R. I. State.

D. Mathematics and Physics—204 Aubert Hall, Attendance 35.
Chairman: Professor C. E. Bennett, University of Maine.
Subject: Objectives of Mathematical Instruction.
Speaker: Professor A. A. Bennett, Brown University.
Discussion: Professor S. H. Kimball, University of Maine.
Subject: Physics and Future Engineering.
Speaker: Professor P. M. Morse, M. I. T.
Discussion: Professor A. N. Guthrie, R. I. State.

E. Mechanical Engineering—305 Aubert Hall, Attendance 25.
Chairman: Professor C. H. Berry, Harvard University.
Subject: Heat and the First Law.
Speaker: Professor J. H. Keenan, M. I. T.

From 12:30 P.M. to 1:30 P.M. the members present were guests of the University of Maine at a luncheon in the Memorial Gymnasium. The attendance was 228. Following the luncheon a brief business meeting was conducted with Dean Dudley presiding.

The Secretary read the minutes of the Tufts meeting and gave the financial report for the year ending December 10, 1937. Both the minutes and the financial report were approved.

Dean Dudley announced the appointment of a Nominating Committee consisting of Dean W. L. Edel, Dean G. W. Case, and Professors C. M. Allen, W. J. Sweetser, F. W. Stubbs and D. E. Howes, and a Committee on Resolutions consisting of Dean Carl S. Ell, Professor A. L. Townsend, and Professor F. N. Tompkins, with the request that both committees report at the dinner meeting.

Dean Case, of New Hampshire and Vice President of the Society, brought the greeting from President Compton who was unable to be present.

Dean Dudley then presented Dean Moreland as the new Dean of Engineering of the Massachusetts Institute of Technology.

Dean Dudley made mention of the fact that at the Texas Meeting of the Society, the Council voted that fifty cents of the five-dollar dues be turned over to the section in the member's area, provided dues were paid before January 15, 1939. He also pointed out that the Council voted to defray the travelling expenses of officers of the Society who appear on the programs of the Section meetings, at least once in three years.

Dean Cloke welcomed those present on behalf of President Hauck who had been unexpectedly called out of town on account of illness in the family.

Dean Cloke then introduced Professor Bradt who explained the arrangements which had been made for the inspection of the campus.

The meeting then adjourned with the period from 1:30 to 3:00 P.M. being devoted to this inspection.

The General Session held in Little Theatre was called to order by the Chairman, Dean S. W. Dudley of Yale, at 3:00 P.M. Dean P. H. Daggett of Rutgers University and member of the E. C. P. D. Committee on Colleges, spoke on "Problems in the Accrediting of Engineering School Curricula." Dean Daggett emphasized the fact that individual curricula were considered separately and that accrediting was on the basis of the quality of staff, the completeness of laboratory equipment, and the content of the curricula. He also emphasized the fact that no attempt was being made to freeze all curricula into a uniform pattern. Following Dean Daggett's remarks there was considerable discussion.

The annual dinner was held at 6:00 P.M. in the Memorial Gymnasium. The attendance was 191.

Following the dinner, members of the Section were entertained by musical selections on two pianos by Mrs. C. A. Brautlecht and Mrs. J. F. Klein.

In accordance with custom, the secretary read the constitution of the Section. Dean Edel, Chairman of the Nominating Committee, presented its report and Dean S. W. Dudley was nominated for chairman for the ensuing year and C. E. Tucker for secretary. The nominations were seconded and the secretary put the nomination of chairman to vote and Dean Dudley was elected. The chairman then put the vote for secretary and C. E. Tucker was elected.

Dean Dudley then called on Dean Carl S. Ell of Northeastern University, Chairman of the Committee on Resolutions, for its report. The following resolutions were presented and unanimously accepted by the Section:

"The members of the New England Section of the Society for the Promotion of Engineering Education in annual meeting assembled at the University of Maine in Orono, Saturday, October 8, wish to express sincere thanks to all those who have made this meeting a happy and profitable occasion:

"To the members of the faculty of the host institution, the University of Maine, and in particular to President Arthur A. Hauck and to Dean Paul Cloke, Chairman of the Committee on Arrangements, for the warm hospitality which has added so much pleasure to this visit. The beauty of the campus, the opportunity to view the University buildings and equipment, and the thoughtfulness of the Committee in planning all details, including the marvelous display of northern lights and the glorious weather, have all been greatly appreciated by the members of the Section.

"Our thanks to Dean Parker H. Daggett for his instructive address this afternoon, to the other speakers and leaders in discussions for their interesting and worthwhile contributions to the program, and to Professor Tristram Coffin, who is to address the members of the New England Section and their guests at this meeting tonight; to the musicians, Mrs. Charles A. Brautlecht and Mrs. John F. Klein, who are bringing us a musical program this evening; to the visiting artists of the Bangor Symphony House for their fine musicale,

"To Mrs. Paul Cloke and her committee who have so graciously entertained the ladies who are here with the Section members,

"To the Harmon Piano Company of Bangor which furnished the two Steinway pianos for our use,

"To the Section Chairman, Dean Samuel W. Dudley of Yale,

the Secretary, Professor Carlton E. Tucker of M. I. T., and the members of the Committee on Program, whose sincere efforts and active interest throughout the year have contributed so much to another successful year for this Section."

Respectfully submitted,

(signed) FREDERICK L. TOMPKINS,
ARTHUR L. TOWNSEND,
CARL S. ELL.

Following the business Dean Dudley called on Professor W. J. Creamer, of the University of Maine, who introduced Professor Tristram Coffin of Bowdoin College. Professor Coffin gave a very interesting address on "Poetry in Everyday Life," illustrating it with poems of his own composition.

During the morning the visiting ladies were taken to the Old Town Canoe Factory and later to the University of Maine Art Gallery. At 12:30 P.M. they joined the men for luncheon in the Memorial Gymnasium. During the afternoon they attended a musicale and tea at the Northern Conservatory of Music in Bangor and at 6:00 P.M. joined the men for dinner.

C. E. TUCKER,
Secretary.

SECRETARY'S FINANCIAL REPORT, 1937–38

October 31, 1938

Receipts:	
Cash on Hand, December 10, 1937	$ 2.71
Cash from Secretary Bishop (69 members)	34.50
Received from 13 members (one paid $1.00)	7.00
	$44.21
Expenditures:	
Printing	$18.00
Postage and supplies	15.39
Telegrams	.94
Cash in Bank Oct. 31, 1938	9.88
	$44.21

C. E. TUCKER,
Secretary, N.E. Section, S. P. E. E.

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.—Editor, M. W. FURR, *Kansas State, Manhattan*

F. T. MAVIS, *Chairman*
H. C. BIRD, *Past Chairman*
F. W. STUBBS, JR., *Secretary*
M. W. FURR, *Editor*
H. T. HEALD
PAUL P. RICE
HALE SUTHERLAND

The Conference to consider problems in Hydraulic Engineering will be held at The State University of Iowa, Iowa City, Iowa, June 12 to 15, 1939.

The final program will be ready soon. Information may be obtained from Dean F. M. Dawson or Professor F. T. Mavis of the local committee.

Regional Conference on Surveying and Mapping will be held at the School of Mines and Metallurgy, Rolla, Missouri, April 6 to 8, 1939, under the auspices of Committee VIII of the Civil Engineering Division of the Society. Professor E. W. Carlton, Chairman of the Local Committee on Arrangements would welcome inquiries.

REVIEW OF PART OF THE CONFERENCE PROGRAM OF THE COMMITTEE ON SANITARY ENGINEERING*—

by M. W. F.

As in all the branches of the profession of civil engineering, the subject of teaching sanitary engineering courses is of much importance. Studies in this realm of engineering, in curriculum content, and teaching are being made by one of the standing divisional committees; that is, Committee III, Sanitary Engineering. The function of this Committee of the Civil Engineering Division is to find and devise ways to improve the teaching of sanitary engineering to undergraduate students. Also, it is to report researches, to suggest changes in the civil engineering curriculum, to propose a curriculum in sanitary engineering. and to make decrees as it deems best.

The last group conference program was presented by the Committee, during the A. and M. College of Texas annual meeting of the Society, under the chairmanship of Professor H. E. Babbitt of the faculty of the University of Illinois. Collaborating in the cause were: Professors R. B. Wiley (Purdue), F. J. Sette (V. P. I.), Thos. R. Camp (M. I. T.), G. M. Fair (Harvard), H. A. Vagtborg (Armour), H. G. Payrow (Lehigh), E. R. Stapley (Okla. A. & M.), and Roscoe H. Suttie (Yale). The topics for discussion and the leading speakers were as follows: "Teaching of Sanitary Engineering to Civil Engineers and the Minimum Laboratory Work Essential in an Undergraduate Curriculum," by H. G. Payrow; "The Proper Scope of the Sanitary Engineering Curriculum," by H. A. Vagtborg; and "Relations with the Sanitary Section of the Mechanical Engineering Division," by H. E. Babbitt, the presiding officer of the Conference.

* Report of other papers of this Conference will appear in the March issue of the *C. E. Bulletin.*

Professor Payrow discussed the above topics in a brief, but interesting manner, emphasizing the problem of the teacher in presenting brief courses of the four-year civil-sanitary engineering curriculum. It was stated that the time allotted to the teacher or teachers of the preliminary and professional courses, according to a previous survey, ranged from about two to six per cent of the time of the four-year schedule. This *limiting time factor* is the first obstacle, and it exists in about the same way in teaching any branch of civil engineering to undergraduates. Also, as strange as it may seem, in schools that are situated in the more densely populated areas of the country, the teacher of civil-sanitary engineering students will find difficulty in holding the students' confidence and interest. The undergraduate student sometimes seems to have a shyness toward sanitary engineering, and the reasons for the tendency are more realistic than fanciful. It is thought that the lack of understanding of the magnitude and importance of sanitary engineering and some general misconceptions of students of the work are detrimental to the efforts of schooling in this field. Moreover, at some schools the student's attention is directed to other fields or branches of civil engineering in which somewhat more complete courses are offered or perhaps all the other courses offered are required, whereas some of the sanitary courses are optional or elective. This situation may detract the students' interest somewhat from the sanitary field. Therefore, for smoothest operation the curriculum should include basic courses with balanced instruction in each field. Specialization in the short time of a four-year period in any of the branches of the civil engineering profession should therefore be discouraged.

As to the minimum laboratory work for the civil-sanitary engineering student, Professor Payrow indicates that the course work should include: (1) qualitative analysis, (2) industrial bio-chemistry, (3) industrial organic analysis or sanitary chemistry, and (4) sanitary bacteriology. Other laboratory courses which should be included, but are less important, are: (5) hydraulics, (6) reinforced concrete design, and (7) electrical and mechanical engineering studies outlined especially for civils. The time for each of the above courses should be scheduled to give from one to two credit hours. This amount of laboratory work will sufficiently correlate the classroom work, train the student in laboratory procedure and manipulation, and serve as an aid to manifest a better interest throughout the brief period of instruction and training.

Will the civil-sanitary engineering student, having had a four-year meager training, succeed in a professional field that has become highly specialized? The answer on the average is *yes*. There are many positions to be filled as city engineer, sanitary engineer of a public works bureau, designer of sanitary engineering structures under either of the above employers or in the employ of a consulting firm, resident engineer on construction work, in the sales field of an equipment concern, et cetera.

To appreciate the social significance of sanitary engineering more fully the civil engineer should imbibe some of the philosophy of the drain man in "The Servant in the House," by Charles Rann Kennedy. Professor Payrow concluded his remarks with a quotation therefrom, "That's what I came 'ere to talk abaht—my job. P'r'aps you'll think as it ain't a tasty subjic, before a lot o' nice, clean, respectable people as never 'ad anythin' worse on their fingers than a bit o' lawn-dirt, playin' crokey; but *some one* 'as to see to the drains, *some one* 'as to clear up the muck of the world! I'm the one. An' I'm 'ere to tell you about it."

ENGINEERING ECONOMY PAGE

Engineering economy is a study of the methods of comparing technical alternatives expressed as far as possible in money terms, used in selecting that course of action which is believed to be the best in the long run.

EDMUND D. AYRES, University of Wisconsin, *Editor*

THE BOOKS OF ACCOUNT DO NOT TELL THE TRUTH FOR REPLACEMENT ECONOMY STUDIES

PROFESSOR DOOLEY CLEAR'S REJOINDER

(The reader will remember that Professor Dooley Clear in the October Engineering Economy Page explains to his class that "net realizable value" of existing equipment must be used as the basis of comparison of the old with the new in replacement studies. One of the professor's students seizes upon the predicament of one responsible for bringing the knowledge of a large sunk cost to the attention of his management as a practical matter he insists the professor cannot ignore.)

Of course the engineer boss might be embarrassed to explain to his board of directors "any big unamortized loss." The loss might be his fault. He might even be fired for it. The possibility of such unamortized loss was one of the things to be considered when the equipment was installed.

Nevertheless, and this is the issue: the equipment is worth what it will fetch, not what the books say. We can't refuse to face the fact merely because the result looks bad on the books. If, for consistency or to avoid blame or because of mere conservatism, the replacement is not made when it should be, or is made when it shouldn't be, the enterprise has taken a step towards disaster.

What is troublesome in the situation is that the books don't tell the truth. To accept the book figure is to be accessory to concealment of the truth. Better to swallow the bitter pill, otherwise, it is sentiment not logic which is in control.

W. D. ENNIS.
Stevens Institute of Technology.

Has Professor Dooley Clear said the last word on this subject? Suppose the recalcitrant Will B. Practical bears down again on the professor:

Professor Clear, I want to believe in that theory of yours but I just cannot get out of my mind a case where a structure or machine is located high up on a mountain top or far out in a desert country where the cost of getting that equipment on location and erected is most of the cost in comparison to its cost at the factory shipping platform, where cost of removal is great and essential to replacement even in this out of the way site, where second hand markets are too remote to influence "net realizable value." Such equipment has value because of its performance and to say that that value is negative for purposes of comparison the day after it is erected because its second hand value is nil and its salvage value is negative just does not make sense. To say it is somebody's mistake if an unamortized loss occurs in such a case just is not fair. Professor, will your theory cover these difficulties?

Do such questions come up in your classroom? How do you answer them?

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*

INSTRUCTION IN ENGLISH IN ENGINEERING COLLEGES

A Report Prepared Under the Direction of the Committee on English of the Society for the Promotion of Engineering Education [1]

PREFACE

BY KARL T. COMPTON

President of the Society for the Promotion of Engineering Education

The teaching of English in engineering colleges presents educational problems of exceptional interest. On the one hand, engineering students are primarily interested in quite different subjects and are inclined to view the study of English as a "chore" which interrupts their more important activities. On the other hand, they feel its importance so acutely, after they have had experience in their careers, that they almost universally wish they had obtained better training in the arts of written and oral expression while in college. Also there is no question but that engineering educators are becoming conscious of a need for more attention to the development of cultural interests and social attitudes in their students—a program in which the department of English has a strategic opportunity.

Perhaps it is the stimulus afforded by such problems which has, in many engineering colleges, led to exceptional energy, originality and skill in English instruction. Yet there is need for improvement all along the line, from the most to the least successful of our English departments, and there is decided interest in a critical study of objectives, methods and results of instruction.

Fortunately a generous grant from the Carnegie Foundation

[1] This report is to be published in successive issues of the JOURNAL OF ENGINEERING EDUCATION. The section entitled "Composition in the Engineering College" will appear in the April number.

for the Advancement of Teaching has enabled the Society for the Promotion of Engineering Education to undertake a serious and comprehensive study of instruction in English in engineering colleges. The results of this study will be published in serial form in the JOURNAL OF ENGINEERING EDUCATION, beginning with the following article by Dean H. P. Hammond. Subsequently these articles will be printed together as chapters of a small volume for general distribution.

On behalf of the Society, I wish to thank the presidents, deans, and heads of English departments of all the engineering colleges, and also selected instructors of English and a large random selection of engineering graduates, who have replied to questionnaires and in many cases given extensively from their own observation and experience. We also thank the Carnegie Foundation for its very helpful coöperation. We are especially grateful for the able and devoted work of the Committee on English which has had charge of the study and which presents the following reports. Under the chairmanship of President E. C. Elliott of Purdue University, it consisted also of Chancellor John G. Bowman of University of Pittsburgh, Professor H. L. Creek of Purdue University, Dean O. J. Ferguson of University of Nebraska, Dean A. M. Greene, Jr., of Princeton University, Mr. John Mills of the Bell Telephone Laboratories, President H. S. Rogers of the Polytechnic Institute of Brooklyn, Professor W. O. Sypherd of the University of Delaware, Professor K. O. Thompson of Case School of Applied Science, and Professor J. L. Vaughan of the University of Virginia.

I

THE FUNCTION OF THE DEPARTMENT OF ENGLISH IN THE SCHOOL OF ENGINEERING

BY H. P. HAMMOND

Underlying any discussion of the place and function of the department of English in the school of engineering there should be recognized and accepted one basic idea: the responsibility for the development in students of the habit of correct expression does not rest on the department of English alone. Every department and every teacher of the school of engineering should be concerned all the time. What is to be developed is the *habit* of correct expression; but the formation of the habit is not to be accomplished only by regular formal instruction, however excellent. It requires constant effort and perpetual vigilance. From many students deeply ingrained habits of speech and modes of thought that have been forming since early childhood must be eradicated. Even for stu-

dents relatively susceptible to learning by absorption from examples this takes a great deal of time, and they must be continuously exposed to the right sort of examples. Conscious and persistent effort is needed.

All educators must assume their shares of this responsibility. Nothing is to be gained by censuring the high schools for the faults in English of students entering college. For that matter the college may not do its job as well as the high school. Habits of writing and of speech, it has been said, are formed before the age of thirteen; and it would seem clear that wrong habits acquired in early youth cannot be eradicated in high school alone. The college must do its part. Moreover, the problem concerns every teacher of an engineering subject just as directly as it does the teachers of English.

As for the department of English itself, in engineering education at least it has four major functions:

First, it is responsible for training students to write and to speak correctly and with facility. To that end there must usually be included in the college courses drill in grammar and in punctuation; and the training must include spoken as well as written English.

The second function arises from the nature of the engineering curriculum, in which there usually devolves upon the department of English the fostering of the liberal or cultural phases of a student's education. For that, in the opinion of many, the chief medium is the reading and study of literature, which therefore should form a part of every college curriculum. This applies to the engineering school fully as much as to any other division of higher education, although from the limitations of their professional program engineers cannot undertake as extensive work in literature as can students who have specialized interests in it. The study of literature in the engineering curriculum should be introductory. It should be a soundly conceived introduction to the systematic reading of good literature and thereby foster in the student a desire for such reading with results that may continue throughout his life. By the examples which it presents it should aid the development of his ability to read and to speak correctly. In this development the importance of work in literature is not realized perhaps as widely as it might be. Most of us, if we trace the sources of our methods and style in writing, will find them probably in what we have read, just as we should find our habits of speech formed largely by what we have heard.

The third function of the department of English is to act as a "service" department for the other departments of the school of engineering; upon request, to assist faculty and students alike in

the constructive criticism of their written work; to prevent lapse into former bad habits of students who have passed their required English courses; and to aid those who wish assistance in the preparation of speeches. This function implies close and well planned coördination with other departments. English departments, however, are usually more than willing to coöperate; and examples are to be found of very effective coördination.

Equally important, although more specialized, is the fourth function: that of rendering service by diagnosing the particular difficulties of students and by prescribing remedies. Speech defects and faulty methods of reading require such treatment; and service is now being rendered in a large number of cases to students whose scholastic difficulties are attributable chiefly to their inability to read textual matter correctly.

To these positive statements of function there may be added a negative: a disclaimer that it is the function of the department of English to train students in the writing of technical reports. That, it seems clearly, is the duty of each engineering department. The organization and forms of expression in such reports, as well as their technical subject matter, are its responsibility. They are part of the obligation which engineering teachers should assume of developing in their students powers of expression. This statement does not imply, of course, that excellent results may not often attend the coöperation of the department of English with the departments of engineering in the criticism of these reports as to details of usage. In many institutions, moreover, departments of English offer courses in technical writing and business correspondence that supplement effectively the training in the preparation of reports and other specialized writing done in connection with courses in engineering.

The statements which have just been made are all derived from the present survey of the teaching of English in schools of engineering. Opinions as to the various aspects of such teaching were collected from several groups—college presidents, deans, professors, and graduates. They were in substantial agreement as to the first three of the functions enumerated above. They did not, of course, agree on all points, and their emphasis varied; but there was nevertheless a considerable measure of agreement on all the previous statements.

The survey also included a question as to measures that might be taken to improve the quality of instruction in English and to obtain better results. Some of the replies described very interesting and original methods. It is hoped that a number of these may be given trial to determine the extent of their practicability; but their description is not a part of the present paper.

In the replies there occurred frequently one basic idea which cannot be emphasized too often: the results of instruction in English depend almost completely on the quality of the staff of the department. That quality, in the long run, depends upon the recognition, compensation, and opportunity for satisfaction of professional ambitions that are offered. Recognition and compensation are two requirements that it is possible to meet. At least it should be possible, for if there is any department of an engineering school in which the best men obtainable are required it is that of English; and its best men should be accorded the same academic rank and title and the same compensation as similar members of other departments. Unfortunately this is not always the case. Unfortunately also, in institutions with a university form of organization the English department does not always assign its abler teachers to instruct engineering students. The third requirement, that of providing an opportunity for the satisfaction of professional aims and ambitions, is not so easily met. But it can be, as is evidenced by some institutions in the quality of their English staffs and in their results.

The answers to the Committee's questionnaire were unanimous in placing English among the basic essentials of the engineering curriculum. The recognition, therefore, of the position of English in engineering education is no longer a problem. Engineers in practice and teachers of engineering alike agree that the ability to write and speak properly is a prime requisite for an engineer.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

F. M. PORTER, *Editor*, University of Illinois

WHY SOME OF OUR ENGINEERING GRADUATES FAIL AS DRAFTSMEN

"Lack of interest; they expect to get rich in a year. They become disgusted unless promoted after the first drawing is made," writes one chief engineer.

"Too much ambition. Most men just out of college seem to think that they are able and ready to take charge of somebody's business and are not willing to work over a drawing board," writes another consulting engineer.

"Lack of interest in drafting (they want to start off in an executive job, and each additional degree makes them poorer draftsmen); lack of knowledge of basic drafting principles, and of a realization that drafting is the chief means of interpreting engineering knowledge," says the chief draftsman of another firm.

The above excerpts were taken from a study being made of industrial drawing room practices and procedures by the Engineering Experiment Station of the North Carolina State College of the University of North Carolina at Raleigh. Over one hundred chief engineers or chief draftsmen representing many different industries and employing over 1200 draftsmen, have been contacted.

Many engineering graduates are initiated into industry via the drawing room. Some of the employers believe they learn the industry more readily by working as tracers, detailers, checkers, and draftsmen before being given an actual design or specific engineering assignment.

One reply stated, "Failure is chiefly due to dissatisfaction at becoming typed (*i.e.* classed as a detailer, or as a tracer, or as a draftsman, as well as to failure to improve in speed, accuracy, clear lettering and the ability to carry through without detailed instructions." Another says "They need 'Horse Sense' and how to use the knowledge gained in college."

From the many varied reasons given for the failure of young engineers, those occurring most frequently in the replies received are listed below in the order of greatest occurrence:

1. Lack of interest in drafting.
2. Lack of proper instruction concerning drafting.
3. Over-estimation of his importance and value.
4. Lack of practical experience.
5. Inaccurate work.
6. Unsuited for drafting work, such as lack of patience. lack of ability to be neat, lacking imagination, lack of ability to visualize and concentrate.

Isn't this group of important faults food for thought to us as teachers? Are we doing a good job of teaching if our product is failing to meet the requirements of industry? Personally I think we should inform our students it is not disgraceful to work over a drawing board. Such work usually offers a stepping stone to new fields with richer rewards, since it provides the young engineer with a useful entering wedge into industry and into his chosen profession.

T. C. BROWN, *Instructor*,
Division of Engineering Drawing,
North Carolina State College.

COLLEGE NOTES

University of Alaska.—Livingston Wright holding the Degrees, B.S. '22 and M.S. '24, M. I. T., has been appoined Assistant Professor of Mining Engineering, filling the vacancy made by the resignation of Associate Professor Ray M. Hendrickson. Mr. Wright has been practicing mining engineering since his graduation and brings a wide range of experience in his field.

Richard C. Ragle, Colorado College. B.A. '33. M.A. '37, has been appointed instructor of geology. He has done extensive geological work in the Rocky Mountain District and holds a commission in the United States Air Corps.

Thomas H. Campbell, Univ. of Wash., '34, M. I. T., M.S. '38, has returned .after one year's leave of absence and resumes his duties as instructor in civil engineering.

L. E. Hough, Univ. of Wash., B.S. '31, has been appointed instructor in civil engineering to fill the vacancy made by the resignation of Henry Joesting. Mr. Hough has been engaged in engineering construction and surveying.

With the opening of the fall semester, the women moved into the reinforced concrete, fireproof dormitory that has just been completed and finished at a cost of $85,000. The men have already filled the rooms in both the old dormitories. A new reinforced concrete building now houses a 175 H.P. B. & W. boiler just completed, with water softening equipment, a new 60 K.W. geared turbo-generator, a 200 ton coal storage bin, as well as equipment moved from the old power house. A 60,000 gallon water storage tank and 500 feet of underground reinforced concrete tunnel have been completed to provide for heat, light, and water service for the campus buildings. These improvements will be completed by the first of November at a cost of $125,000. As additions to the permanent buildings on the campus, they will greatly increase the efficiency of the University Plant, and will provide facilities to meet the ever growing demand for university training in Alaska.

This season's work in the mining districts has been unusually long on account of the favorable weather, but practically all the upper classmen are now enrolled, as well as a large Freshman Class. The long summer vacation enables the students in Alaska to take advantage of seasonal work. Practically all of the students are self-supporting to some extent.

Howard Lee Davis has been appointed Director of Placements at the **Polytechnic Institute of Brooklyn.**

Mr. Davis was born in Cincinnati, Ohio, and attended Sheffield Scientific School at Yale University where he majored in mechanical engineering. After graduation he held several sales and supervisory positions connected with the light and power industry in Westchester County, New York. In 1906 he entered the employ of the New York Telephone Company, later becoming Engineer of Outside Plant, a position which he held until 1925, when he was appointed Director of Technical Employment and Training.

During his thirteen years incumbency of this post Mr. Davis was responsible for the recruiting and introductory training of the technical and non-technical employees for the commercial, plant, traffic and accounting departments of the company. His interest in the training and post-graduate education of young men has brought him in contact with many of the leading technical colleges in the East.

The Mechanical Engineering Faculties of **Stanford** and the **University of California,** Berkeley, hold bi-semester joint meetings, alternately at the respective institutions. Members of the staff of the Engineering Colleges who are interested in Applied Mechanics attend these meetings. The number varies from thirty to fifty.

The first meeting last semester was devoted to a review of Galileo's contributions in Mechanics and Elasticity by Professors D. H. Young and S. P. Timoshenko respectively. The second meeting included a presentation of Production Processes in Industrial Determination and Furnaces of Thermal Stresses in Hollow Cylinders by the Photo-Elastic method by Professors J. E. Dorn and E. E. Weibel of California.

The meetings are preceded by an informal dinner.

Clemson College.—The staff of the School of Engineering has been enlarged by three men this fall—J. B. T. Downs in Mechanical Engineering, J. T. Massey in Electrical Engineering, and G. A. Douglass in Drawing. Mr. Downs has been Instructor in Machine Design at Stevens Institute of Technology where he received his undergraduate training, and was granted the M.S. degree there in 1938. Mr. Massey received his B.S. in 1938 from North Carolina State College. Mr. Douglass received his B.S. degree from Clemson College in 1931. He has been two years on active duty in CCC Service, called on his Reserve Officers Commission, and has had considerable experience in engineering construction. Also there have been some changes. T. S. DuBose, formerly Assistant in Mechanical Engineering and Shop, has resigned to accept a fellowship at Lehigh University and pursue graduate work toward

an advanced degree in Mechanical Engineering. His work is being taken by J. K. Chapman, who received his B. S. degree in Electrical Engineering from Clemson College in 1938. Clemson College is exchanging a visiting faculty appointment in Electrical Engineering with Cornell University. A. B. Credle, Assistant Professor of Electrical Engineering, is exchange teacher in Electrical Engineering and in charge of operation of the radio station at Cornell University where he is also working on his doctorate. He holds B.S. and M.S. degrees in Electrical Engineering from Cornell and has taught at Clemson for the past five years. Dr. Smith is exchange teacher at Clemson. He holds B.S., M.S., and Ph.D. degrees from Cornell in Electrical Engineering. He has been Instructor in Electrical Engineering and in charge of operation of the radio station there for the past five years.

The leave of absence of Professor J. A. Stevenson of the Civil Engineering Department, as Engineer for the Agricultural Adjustment Administration, has been extended another year, to permit further work in coördination of aerial surveys and mapping. A. M. Quattlebaum has continued in Mr. Stevenson's place.

A group of precision machines used in the private research laboratory of the late B. A. Behrend, Vice-President of Westinghouse Electric and Manufacturing Company, has recently been secured by Clemson. Their value has been estimated at $50,000. In accordance with provisions in Mr. Behrend's will, these were to be made available to some technical school, and the widow selected Clemson.

Enrollment in Clemson this year is 2108, exceeding all previous figures. New dormitories built two years ago are already inadequate, and the contract has just been let for suitable added permanent dormitories to house several hundred more students. Construction will begin in early January. Other projected construction includes a new post office, addition to the heating plant, and added sewage and water treatment facilities. Recently occupied is the $500,000 Textile Building which houses the School of Textiles and Textile Engineering and a coöperative division of Cotton Spinning Research of the United States Department of Agriculture.

Colorado School of Mines.—J. Harlan Johnson, associate professor of geology, was one of the leaders on the recent field trip through northern New Mexico of the Panhandle Geological Society comprising members from Colorado, New Mexico, and West Texas. On the two-day trip the party studied the Pennsylvanian section as well as higher strata in the Sangre de Cristo mountain area.

Work is underway on the School of Mines Housing Project. When completed it will comprise two apartment buildings, ten

houses, and a central heating plant, and will provide thirty-one living units for faculty members and married students. Its location is the former Golden golf course near the southwestern part of the campus. The cost of the project, a result of two years of study by President Coolbaugh and the board of trustees will be $175,000. Present plans for the apartments call for two twelve-unit, two-story brick buildings, providing eight one-room, eight two-room, and eight three-room apartments. The houses will be both single-story and two story brick, and each will have a combination living and dining room, two bedrooms, a kitchen and bath, and a garage attached as an integral part of the house.

"Mathematics for Geologists and Geophysicists" is a new course being offered by the department of mathematics. The principal subjects presented are: a review of differential and integral calculus, with their main engineering applications; harmonic motion and the significance of parameters; characteristics of oscillating bodies, free and forced; inertia systems; acoustic applications; analogies in gravitational, magnetic and electric fields, theory of electric networks, applications of hyperbolic and Bessel's functions; theory of heat conduction in rocks; other applications of Fourier's series, and related topics.

The Department of Geophysics has announced the revision and enlargement of the course "Electronics in Geophysics." The purpose and content of the course as outlined by the department are as follows:

> The purpose of this course is to develop in geophysics students an understanding of alternating current phenomena and vacuum tube circuits as applied in various branches of geophysics. Particular stress will be laid on experiments with circuits of fundamental significance rather than special applications. A.C. bridges will be used in the determination of impedances, capacitances, self and mutual inductances and in evaluating the characteristics of filters and transformers. A part of the course will be devoted to applications of the cathode-ray and other oscillographs in circuit analysis. Fundamental characteristics of vacuum tubes will be discussed and measurements will be made of internal capacity, emission, plate voltage and plate current; vacuum-tube-voltmeters and amplifiers will be tested.

Carl O. G. Wittig, assistant professor of Mechanical Engineering for the past ten years, has resigned his position to become head of the department of Mechanical Engineering at the Catholic University of America in Washington, D. C. He takes up his new duties immediately after the close of the fall semester here.

Cornell University.—William Abbett Lewis, Jr., engineer with the Westinghouse Electric and Manufacturing Co., in Pittsburgh,

Pa., and a Westinghouse lecturer in electrical engineering at the University of Pittsburgh, has been appointed director of the School of Electrical Engineering. The appointment was approved by the Board of Trustees on the new director's thirty-fifth birthday, making him one of the youngest men ever selected for high administrative office at Cornell. He took office on February first. A graduate of the California Institute of Technology, Lewis holds the B.S. with honor (1926), the M.S. with honor (1927), and is the only student of electrical engineering ever to receive from that institution the Ph.D. summa cum laude (1929).

Dr. Lewis will be the third director of the school, succeeding Professor Paul M. Lincoln, who has served since 1922, continuing as acting director after his formal retirement last June. The first director was Professor Alexander Gray. Although Cornell organized in 1883 the first course in Electrical Engineering anywhere in the world, and later established the first department of electrical engineering in this country, the present School of Electrical Engineering dates from 1921, when engineering instruction was reorganized and the present College, with constituent schools, was created.

Oscar J. Swenson has been appointed assistant professor of chemical engineering. Professor Swenson, who holds the degree of Bachelor of Chemical Engineering with distinction from the University of Minnesota, and Ph.D. with a major in the same field from the same institution, has had four years of teaching experience at Minnesota and three years as chemical engineer in the industrial engineering division of the E. I. duPont de Nemours Company.

Other members of the faculty of the new school are Professors C. W. Mason and A. W. Laubengayer of the Department of Chemistry and Professors W. N. Barnard and A. C. Davis of the Sibley School of Mechanical Engineering. The School of Chemical Engineering will grant the new degree of Bachelor of Chemical Engineering and will also offer graduate work in this field.

Eleven instructors and one full-time assistant have been appointed to the staff of the College of Engineering, Cornell University, for the current academic year, in addition to the two professors and the assistant professor previously announced. A. B. Credle, '30, who is assistant professor of electrical engineering at Clemson College is instructor in the School of Electrical Engineering for one year, exchanging positions with H. G. Smith '30 of the Cornell staff, who has gone to Clemson.

Other appointments, all in the Sibley School of Mechanical Engineering, follow: Reginald B. Allen, B.S. in A.E. '38, assistant in administrative engineering; Lewis S. Bock, M.E. '29, who has had experience with the Brooklyn Union Gas Company and other con-

cerns, instructor in administrative engineering; L. D. Conta, who holds B.S.M.E. and M.S. degrees from the University of Rochester and was a John McMullen Graduate Scholar last year, instructor in experimental engineering; John Georgian, B.M.S. from the University of Minnesota, instructor in machine design; G. M. Hutchison, B.S.M.E., Virginia Polytechnic Institute, who has been employed by the General Electric Company, instructor in engineering drawing; W. H. Kreamer, B.M.E., Rensselaer Polytechnic Institute, who has been employed by the General Electric Company, instructor in engineering drawing; N. O. Myklestad, graduate of the Royal Technical College, Oslo, Norway, who has had experience with several industrial concerns and has been taking graduate work at the University of California, instructor in mechanics; E. J. Schiller, Jr., B.Sc., Brown University, who has been employed by the General Electric Company, instructor in machine design; J. H. Shank, who holds the M. E. T. degree from the Colorado School of Mines and has been employed by the Republic Steel Company, instructor in experimental engineering; D. D. Sherrill, B.S.M.E., University of Colorado, who has had three years of experience with the U. S. Bureau of Reclamation and has taught at the University of Iowa, instructor in machine design; and G. K. Williams, E.E. '32, who also holds the M.M.E. from Cornell and has been employed by the Westinghouse Electric Company, instructor in mechanics.

Harvard University.—My attention has been called to the table on page 371 of the January 1939 issue of THE JOURNAL OF ENGINEERING EDUCATION, in which Harvard College is listed as having 8 evening students. The figure 8 should have been in the next column which is headed "Others" representing the "4 dropped Fr.; 2 oeC; 2 prov.Soph." which were reported on the questionnaire which we returned to you.

Massachusetts Institute of Technology.—Most spectacular of Massachusetts Institute of Technology's recent developments is the wind tunnel designed by Dr. Peters of the Aeronautical Engineering Department and dedicated recently to the Wright Brothers, in recognition of their experimental methods of airplane development.

The tunnel is a welded, rectangular metal tube, ninety feet long and forty-five feet wide, varying in diameter from ten to twenty feet. Adjoining the tunnel is a small, yellow brick building, which houses the recording instruments. The tube at present is uncovered and unpainted, but after oxidation has roughened the surface, a coat of aluminum paint will be put on.

The principal feature which distinguishes this tunnel is the control of the air pressure in it. There are a few smaller tunnels in

which the pressure can be raised, but this is the first in which pressure can also be reduced. In accordance with Reynold's Theorem, if the density of the air in the tunnel is increased four fold, the effects of an air stream on a quarter size model will be identical with those of normal air on a full size plane. When the density of the air is reduced, conditions of altitudes up to thirty-seven thousand feet can be simulated. The velocity of the air in the tunnel can reach four hundred miles an hour. The heat generated by the air at this speed will be dissipated in winter to cold air outside, but in summer it will be necessary to water cool the tunnel.

The power to move the air at this high speed comes from a two thousand horsepower electric motor, which drives a thirteen foot, six bladed, variable pitch propeller. This propeller is interesting, particularly since the method of its construction may be widely used for airplane propellers in the future. It is made by coating a core of wood with a hot, resinous plastic, which impregnates the wood when the blade is moulded at great pressure. This construction eliminates crystal fatigue, a cause of failure in metal propellers; it also makes a light propeller, so that, if it should shatter, the damage done is reduced. Also to protect from flying pieces of a broken blade, there is a band of extra steel around the tunnel at the propeller mounting.

One of the most interesting problems in the design of the tunnel, one which Professor Markham undertook, was that of locating the balances and recording apparatus. To maintain the required pressure in the tunnel, it must be tightly sealed; therefore no one can get at the balances while the tunnel is in operation, nor could any one stay in the tunnel, because of the pressure. Aerodynamic forces and moments on a model will be measured by the forces required to maintain the equilibrium of supporting balances having six degrees of freedom. These forces are transmitted electrically to dials in the control room, where they can be recorded. The position of the model during tests can be changed electrically from the control room. In order to see if the model is still intact during a test, there is a glass port between the control room and the section in the tunnel where the models are placed.

The section for the models is elliptical, ten feet wide and seven and a half feet high. Models of parts of planes or of complete planes will be placed in it for tests.

The tunnel is now in operation, measuring and checking the accuracy of the balances. These measurements will be taken all winter, and when complete, will be compared with results obtained on other of the world's tunnels. In January a report of the proceedings to date will be submitted to an aeronautical meeting in New York City.

When the calibration of the balances is finished, the tunnel will be used half time for the research of the faculty and half time for the research of industry. Undergraduate work will continue on the old wind tunnel.

By use of the Wright Brothers Wind Tunnel many new calculations can be made concerning various conditions of flight, and many discoveries will be made which will further the advance of air progress.

Recently President Compton dedicated to William Barton Rogers a beautiful new addition to Technology. This building, topped by a dome one hundred feet high, is certainly a fine memorial to so illustrious a gentleman. However, it was also built to fill the more necessary and practical needs of the architecture students. Half of this new wing is now occupied by our very welcome schoolmates who heretofore worked in the old Architecture Building of the "Tech on Boylston Street." It is an excellent new quarters that has been provided for them and the conveniences gained will soon erase the fond memories they still hold for the old Rogers Building.

Technology has opened a new course called Biological Engineering of which great things are hoped.

Some years ago it appeared that the art of engineering and the science of chemistry could be usefully combined in a curriculum of chemical engineering. The possibilities of employment of the chemical engineer at that time was problematical. The sponsors of that new curriculum had faith that men, properly trained in the proposed field, would find their place in usefulness. The record of successful performance by our graduates in Course X speaks for itself. Biological engineering is at present in a similar situation to that which faced chemical engineering in its infancy.

Biological engineering is not merely an invention of the thinking process; it is recognition of an existing situation and an existing need. There is every expectation that the student who has met the requirements of this new curriculum will be so equipped technically that by combining his technical information with industry and ingenuity he may enjoy success in problems of research and of pure and applied biology, as in medical schools, hospitals, foundations and biological institutes, universities, food industries, pharmaceutical manufacturing, industrial hygiene and in various government laboratories connected with agriculture, food, milk, and standards. The field is a virgin one for the man of ability, imagination and courage. It offers a chance for creative work. There are no ruts in this field into which the biological engineer may stumble. His progress will depend upon his own power and initiative. No

frontier of applied science has ever appeared to be more fertile ground from which to arrest a useful and interesting livelihood.

Missouri School of Mines.—As a result of the death of Professor L. E. Garrett, D. F. Fisher, Jr., a graduate of Pennsylvania State College in State College, Pennsylvania, has been appointed instructor in the Mechanics Department. R. Z. Williams, Assistant Professor of Mechanics, has been appointed acting head of the Department to succeed Professor Garrett.

A number of the faculty and alumni of the School of Mines and Metallurgy are active in a movement to have the Missouri legislature, now in session, pass a registration law for engineers for Missouri following the uniform law that has been passed in a large number of other states.

Norwich University has established a bureau of industrial research to coöperate with Vermont manufacturers and business enterprises. The director of the bureau is Major Douglas E. Howes, associate professor of electrical engineering. The bureau consists of a director, and heads of departments and other members of the department to be designated by him, involved in specific studies.

The purpose of the bureau will be especially to assist the smaller industries, which are not large enough to support research organizations of their own.

The impetus to the organization of the bureau came from the Vermont division of the New England Council, of which Mortimer R. Proctor is chairman. The New England Council has encouraged the formation of an organization for industrial research in each New England State. With the Norwich bureau under way, scientific investigation in the problems of industry under the general auspices of the council will be available in every State in New England.

The bureau at Norwich will maintain as accurate a survey of the Vermont industries as possible, attempt to arrange with the industries and the facilities of the University for the solution of industrial problems, maintain as complete a catalogue of industrial information as possible, contact similar organizations in New England for the purpose of steering inquiries to the proper sources when the university is unable to supply the information thus preventing duplication of effort, promote meetings for related industries, and supply all assistance possible to Vermont industries which seek its coöperation.

University of Notre Dame.—Carson P. Buck has been appointed to the Department of Engineering Drawing, replacing

Francis X. Ackerman, former head of the Department, who has been retired after many years of service. Mr. Buck received his undergraduate training at the Clarkson College of Technology, B.S. in C.E., 1933; his graduate training at St. Lawrence University, M.A., 1936. He has had three years experience with the U. S. Coast and Geodetic Survey, as well as other industrial experience. He comes directly from the Vocational High School in New York City, where he has taught for a year and a half.

P. M. Pirchio, who has been a member of the Department since 1924, has been appointed as the new head of the Department.

Robert Eikenberry joins the Department of Aeronautical Engineering as a new instructor this year. He comes from the University of Michigan from which he received his M.S. in Aero. Engr. in 1936. He is, at present, engaged in a research problem for his Doctor's Dissertation. His undergraduate work was at Swarthmore College, B.S. in Physics, 1934. While at the University of Michigan, he was flying instructor and superintendent of equipment of the University of Michigan Glider Club. He has had soaring experience in three national contests.

The Chemical Engineering staff has been augmented by the addition of Mr. Ernest J. Wilhelm, who comes from the Research Division of the New Jersey Zinc Company, where he has been making investigations in the metal section. Mr. Wilhelm received all of his education at Notre Dame, where he took his Ph.D. in 1930.

West Virginia University.—Chas. E. Lawall, Head of the School of Mines, has been elected Acting President of the University following the resignation of President C. S. Boucher, but at present has not relinquished his duties in connection with the school. W. W. Hodge, Head of the Department of Chemical Engineering, has been granted a year's leave of absence to organize a program of research for the treatment of the industrial wastes of the steel industry as they affect water supplies. The research is sponsored by the American Iron and Steel Institute. Professor Hodge is located at Mellon Institute.

Three new instructors were added to the staff in Chemical Engineering this year. R. C. Cantelo came from the oil industry at Whiting, Indiana. O. E. Brown from the University of Wisconsin and M. J. Skeeters from Purdue University.

Much new equipment has been secured for the engineering laboratories. Mechanical engineering is completing a new internal combustion laboratory with new power brakes and two Diesel and two gasoline engines. Chemical engineering has recently obtained a new crystallizer, a humidity and temperature control dryer, a bubble cap distiller, a double effect evaporator and an Oliver

Rotary Filter press. The Department of Mechanics has a new 200,000 pound hydraulic testing machine.

Enrollment continues to grow, the increases for the last two years being about 10 per cent over the preceding years.

A new Mineral Industries Building has been planned to relieve the present congestion in the college. It will house Mining, Chemical engineering and Geology.

The **Worcester Polytechnic Institute** Board of Trustees has authorized President Ralph Earle to proceed with a million-dollar program of building construction and campus development. It will be the largest educational building program ever undertaken as one project in this city, which is the home of four colleges. W. P. I. now has a restricted enrollment and President Earle states the trustees contemplate no increase. The Freshman class registration is limited to 180.

The program embraces an addition to Salisbury Laboratories, now in construction, and remodeling of the main building, at a cost of $100,000; erection of a memorial building for student activities, to include a library and auditorium seating 975, at a cost of $350,000; erection and equipment of a mechanical engineering building, $400,000; refitting old mechanical laboratories for use of the civil engineering department, $65,000; development of a quadrangle (including land already purchased), razing of buildings, relocation of tennis courts, erection of a footbridge connecting the East and West campus, refitting of Boynton Hall administration offices, cultural departments and faculty lounge, $85,000.

The Memorial building will be erected first. Bids will be called for this Spring, and it is planned to have ground broken and work underway by Commencement. It should be completed by June 1940, and the whole construction program by the opening of the 1942 Fall term.

The center for student activities is being given to the college by generous friends, as a memorial to a man who was prominent in the early development of the Institute. His name will be given to the building at the time of its dedication. The site selected is adjacent to Sanford Riley Hall, freshman dormitory, to which the memorial is to be connected by an arcade at the auditorium level. The architecture will be in the Tudor style, carried out in brick laid in Flemish bond and trimmed with gray cast stone, to conform with that of the dormitory and Alumni Gymnasium. The auditorium will be equipped with an organ, sound-picture equipment, and an ample stage. It will be the scene of all student assemblies, including daily chapel exercises now conducted in Sinclair Hall.

Plans for the mechanical engineering building are now being

prepared, and it is expected construction will be started within a year. It will be opposite the old laboratories and adjacent to the gymnasium, forming with the memorial the third side of the new quadrangle. Erection of this building is made possible by liberal bequests of two graduates, Moses B. Kaven, '85, and William L. Ames, '82. Trustees and alumni propose to secure additional funds for its endowment, for equipment, and for other items of the campus improvement program.

Grading and landscaping of the new plot plan for the western portion of the campus will follow the construction of buildings. At that time the civil engineering department will be moved into what are now the mechanical laboratories, and present civil engineering quarters in Boynton Hall will be remodeled for use of the mathematics department and for faculty meeting rooms.

NECROLOGY

In the death of W. E. Barlow, professor of metallurgy and metallography, on December 22, the faculty of the Virginia Polytechnic Institute suffered an irreparable loss. Not only was Dr. Barlow a distinguished scientist and scholar; he was also an inspiring teacher, a man of broad interests and culture, and a Christian gentleman whose sterling character impressed itself on all who had the privilege of knowing him.

William Edward Barlow was born in Bury, Lancashire, England, on May 11, 1870, the son of William Smythe and Mary Yates Barlow. He received his early education at the Bury School and in 1889 was awarded both the Key Exhibition and the Openshaw Scholarship at Cambridge University. He entered St. John's College, Cambridge, and began studying for the Natural Science Tripos. In 1892 he left England for travel and rest; after spending several months in Utah and Colorado, he became an instructor in chemistry at the State University of Iowa, where he remained until 1901.

He returned to Cambridge at intervals, taking his B.A. degree (first class) in 1895 and his MA. degree in 1899. Securing a leave of absence from the University of Iowa in 1901, he went to Germany and spent two years at the University of Goettingen, from which he received his Ph.D. degree (magna cum laude) in 1903. He then returned to Iowa University as assistant professor of chemistry.

Dr. Barlow came to Virginia Polytechnic Institute in 1904 as assistant professor of industrial chemistry and metallurgy. He became associate professor at the end of the year and was made professor of metallurgy and metallography in 1906. Not only did Dr. Barlow initiate the study of metallography at Virginia Tech; he also developed the work in metallurgy from a single course to an independent curriculum leading to a degree. From 1908 to 1919 he was dean of the graduate department. He also found time for much original research in his chosen field, the results of which were published chiefly in the *Journal of the American Chemical Society*. At the time of his death he was a fellow of the American Association for the Advancement of Science, a member of the Sigma Xi and Phi Kappa Phi honor societies, an Episcopalian, and a Mason.

BOOK REVIEWS

Internal Combustion Engines. H. E. DEGLER. John Wiley and Sons.

This treatise on the internal combustion engine fits the needs of the undergraduate student of Engineering. The prerequisite subjects might be simple chemistry and strength of materials, although the latter could be omitted since all formulas used are put in their final, useful form.

The author realizes that the undergraduate has not had the experience of dissembling and assembling internal combustion engines.

The order of presentation, Combustion, Cycles in Present Day Use, Practical Engines, Design of Engine Parts and Testing, is logical. Considerable detail concerning the Diesel Engine is included. The final chapter, "the Economics of Gas and Oil Power," is well handled from an Engineer's viewpoint. The latest codes on the testing of both internal combustion engines and their specific offspring, the automobile engine, are found in the appendix.

It is evident that this book is not intended to replace standard works by such authors as Ricardo, H. T. Tizard or D. R. Pye.

This book is now being used as the text for our "Internal Combustion Engine" course at the College of the City of New York.

STEPHEN J. TRACY, JR.

Electric Power Transmission and Distribution. L. FRANK WOODRUFF. Second Edition. John Wiley and Sons, Inc. 257 pages. Price $3.50.

Most revisions or second editions of text books are made inferior to the original by the addition of uncorrelated material making the text too voluminous or by the cutting out of fundamentals to make room for new material.

Mr. Woodruff in his second edition of "Electric Power Transmission and Distribution" did not make either of these mistakes. The new edition has 257 pages against the original of 340 pages. This was made possible largely by his treatment of line reactances by the method of Geometrical Mean Distances instead of Flux Linkages which makes line reactance calculations a relatively simple problem.

Practically the entire text has been rewritten except for basic concepts such as skin effect. Two chapters have been added, one

on power limits and stability and the other on calculation of fault currents.

The new edition is a notable advance from the standpoint of teachability.

PHILIP E. RUSH

Mechanics for Engineering Students. YOUNGER. International Textbook Co.

Professor Younger has written a well-arranged and readable book on mechanics. The large number of very practical applications of theory which are included should be very welcome to mechanics teachers.

The book is divided into five sections as follows: Statics, Kinematics, Dynamics of Rigid Bodies, Methods of Momentum and Energy and Method of Dimensions. The text is divided into forty-seven chapters and the author points out that the division into short chapters is an advantage from two standpoints. It aids in keeping a number of class sections at the same stage of advancement and helps in an orderly presentation and study of class material.

In statics the author includes a discussion of the "method of virtual work" in addition to the usual methods of equilibrium. Also from time to time throughout the text reference is made to the historical development of mechanics which adds considerably to the interest of the text.

In the section on "Dynamics" in addition to the other methods, D'Alembert's method is presented as the most practical for engineering students. Throughout the text the author emphasizes basic methods and concepts as being important rather than formulas and results.

The growing importance of methods of dimensions has led the author to include a section dealing with this subject. He discusses the necessity that equations be homogeneous and also the value of dimensional analysis in determining the possible form of an equation from experimental observations.

There are 635 problems included in the text arranged at the end of each chapter in the order of their difficulty. The complete solutions to a number of the problems are given, illustrating the application of theory. These problems are especially noteworthy due to their extremely practical nature.

The "reviewer" believes that this text is very well suited to its purpose, *i.e.*, as a text for a one-year course in analytic mechanics for engineering students.

THOS. G. BECKWITH.

Problems in Engineering Thermodynamics and Heat Engineering. Second Edition. CHARLES W. BERRY, CARL L. SVENSON, AND H. CARLTON MOORE. John Wiley and Sons, Inc. 178 pages. $1.25.

This book contains nearly one thousand problems covering the theory and practical application of thermodynamics to engineering. The problems are grouped logically into fifteen chapters, each of which covers some particular phase of the subject.

To show the scope of the book a few of the chapter headings are listed: "Introduction, Units, and Specific Heat," "Internal Combustion Engines," "Steam Turbines," "Boilers and Accessories—Fuels and Combustion," "Air Compressors," "Heating and Ventilating," "Miscellaneous Mechanical Engineering Equipment."

Answers are given to part of the problems. Problems are printed only on one side of each sheet and the left edge of the sheet is perforated. If desired the problem can be readily clipped from the book and attached to the solution.

The authors state that in the second edition the scope of the book has been increased by adding new problems at the end of the chapters, and that all known numerical errors and omissions have been corrected.

Such a book should be of considerable value in conducting classes in thermodynamics, since the number of problems available and their classification make it relatively simple to select one to illustrate any point desired.

G. O. MANIFOLD.

Strength of Materials. First Edition. NORMAN C. RIGGS AND MAX M. FROCHT. 432 pages. Ronald Press Company. 1938.

The material covered in this text is indicated by the chapter headings: Stress and Strain; Two-Dimensional Stress Analysis; Thin Cylinders and Riveted Joints; Shears and Bending Moments; Stresses in Homogeneous Beams; Stresses in Non-Homogeneous Beams; The General Case of Bending and Short Columns; Torsion; Deflection of Beams; The Three Moment Equation, Conjugate Beams, Moment Distribution; Columns, Curved Beams and Hooks; Strain and Energy; Impact Stresses; Elements of Photoelasticity, Stress Concentrations; Failure of Materials. To give further description the authors make the following statements concerning their work: they have tried to present a unified, teachable book; the material has had extensive use in lithograph form; deflection by double integration is omitted, making place for some work in the Cross method of moment distribution; there is a brief treatment of the theory and application of photoelasticity to the study of stresses,

such material stimulating student interest; stress concentration is demonstrated as being the chief cause of failure in fatigue.

The text covers the usual work in Strength of Materials but includes the increasingly important studies of photoelasticity and stress concentration. This material is conveniently placed so that it can be omitted from the briefer courses. The chapters on riveted joints and on stresses in homogeneous beams have increased value because of simple photoelastic examples.

The treatment of the fundamentals is largely the same as in other texts. It is believed that the material on Mohr's circle, the ellipse of stress, and the ellipsoid of stress presented in chapter two might better be omitted in the basic work. There should be material included on the design of riveted joints. The inclusion of the Cross method of moment distribution is good, but the work basic to this method is insufficient for the average student.

A valuable innovation is the summaries, at the end of each chapter, of the important topics covered and the formulas developed.

The material in the text is sufficient for a complete course in strength of materials and may readily be used in the briefer courses by omitting some of the chapters.

MARTIN L. RUTTER.

Applied Descriptive Geometry with Drafting-Room Problems. FRANK M. WARNER. Second Edition. McGraw-Hill Book Company, Inc. New York and London. 1938. xiv + 228 pages. $2.25.

"The best way to learn how to use a tool" says the author, "is to spend less time looking at the tool and more time in using it." The fallacy in this figure is due to the actual disparity between the socalled mathematical tools and the tools of the machine shop. One who has never before seen a lathe may perhaps evolve a theory of its uses by contemplating the lathe and running down the reason for existence of each of its gagdets. Actually, however, even the operator is not as a rule familiar with the mechanical theories which the designer applied in constructing the lathe, so that his contemplation of the machine is bound to be more or less superficial, and he would not be expected to exhibit much versatility in modifying its special features to adapt it to less usual purposes.

In mathematics, however, the user of a particular tool must first construct the tool before he can use it intelligently. He does not, of course, necessarily design it himself but he must at least, in acquiring it, pursue more or less the same line of thought as he who did design it. He must follow the theoretical development of a

"tool" to be made keenly aware of its power. limitations, and relevancy in the field of its applications. The more one contemplates (thinks vigorously and rigorously about) a fruitful, theoretical tool the more insight and flexibility one gains in its practical use. A theory is something that *must* be made the subject of profound contemplation if one is to see all its facets, all its implications, and all the uses. A theory is a light illuminating facts; by that light we see how to coördinate and utilize the facts to the maximum advantage. Without that light we stumble blindly in the dark and obtain correct results, when we do, by the grace of accident.

The author himself would probably give assent to these by no means original views. Indeed the essence of his book, despite the mild introductory disclaimer is actually theory but theory imbedded, so to speak, in practice, theory which is motivated by practical requirements, and unfolded along with the solution of the problems.

The book seems to the reviewer to be a very desirable one as a working text and could be read with profit by engineers and pure mathematicians alike, particularly those among the latter who teach courses requiring skilfull blackboard drawing technique, such as solid geometry and integral calculus. The book is attractively printed and bound and contains, as one might expect in a work of this nature, excellent figures. The problems are numerous and good.

A. E. STANILAND.

G-E Campus News

A BIG SQUEEZE

IT TAKES a lot of squeeze to put a 1,000,000-volt x-ray equipment in a container only four feet in diameter and seven feet long, especially when its less-powerful predecessors required a special building 62 feet long, 32 feet wide, and 36 feet high. But recently, without much ado, G-E scientists applied the necessary squeeze and completed some surprisingly compact x-ray equipment.

Such squeezing naturally involves a few innovations in design. So innovations were introduced. The 11-section x-ray tube was put inside the novel transformer, in the space normally taken by an iron core. Gas having an impressive-sounding name, dichlorodifluoromethane, was used instead of oil as an insulating medium, 100 pounds of this gas doing the work of six tons of conventional oil.

Then the equipment was mounted in the grounded metal container, thereby enclosing the 1,000,000-volt circuit and eliminating the hazard of electric shock. Looking at the apparatus, you note a striking absence of moving parts, for the control of the apparatus is essentially electrical.

The first of the new units will be installed this spring in Memorial Hospital, New York City, providing medical science with another powerful weapon in its war on disease.

THE "HOUSE OF MAGIC" BECOMES TWINS

THE world-famous G-E "House of Magic" show has become twins. It had to, for it was placed in the predicament of having to be in two places at one time—the New York and the San Francisco Fairs.

One twin—directed by R. L. Smallman, Calif. Tech '33 and ex-Test man—is already holding court on San Francisco's Treasure Island, site of the Pageant of the Pacific. The other makes its bow April 30, opening day of the New York World's Fair. Its director is W. A. Gluesing, Wisconsin '23, also an ex-Test man.

The thousands of visitors to these Fairs will see such feats of modern magic as a voice-controlled toy train, a magic carpet, zigzagging pictures of sound. They will see the stroboscope, which makes it possible to see the spokes of a whirling wheel just as if the wheel were motionless.

However, entertaining as these demonstrations are, they represent far more than mere tricks of modern magic. They symbolize the work in pure science that is constantly taking place in G-E research laboratories—work which is the basis of General Electric's contributions to the world of the future.

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